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14. ABSTRACT
The purpose of this TOP is to provide the tester standardized testing methodologies and procedures to assess dismounted handheld detection systems in order to ensure overall safety, performance, and reliability of the system. It describes activities necessary to ensure safety is designed into the system under test, and to verify detection performance meets system requirements (such as, to detect landmines, improvised explosive devices and their components, as well as, ammunition cache and/or unexploded ordnance).

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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 04-2-090A 8 January 2015
DTIC AD No.

TESTING OF HAND-HELD MINE DETECTION SYSTEMS

*This TOP supersedes TOP 04-2-090, Mine Detectors, dated 18 August 1969.

Approved for public release; distribution is unlimited.

1. SCOPE.

a. This Test Operations Procedure (TOP) describes a systematic approach to “safety, performance, and reliability” testing of dismounted handheld detection systems used for landmines, improvised explosive devices (IED) and their components (e.g., pressure plates, command wire, triggering devices), unexploded ordnance, and buried ammunition caches. The objective of the procedures outlined in this TOP is to provide methods of assessing the technical performance effectiveness, engineering, safety, and technical characteristics of these dismounted, handheld detection systems under test (SUT). This document will point to other TOPs, Military Standards (MIL-STD), and if necessary, International Test Operations Procedures (ITOP) and North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG), for more detailed explanation of specific test activities.

b. The TOP also provides the basis for comparing present techniques and instrumentation and for improving and optimizing existing technologies (in terms of sensor efficiency and effectiveness, reduction of false alarm rate, time required for operations. etc.). However, this TOP is seen as a crucial aspect for the development of new technologies, and it is recognized that this TOP will positively contribute to increase the credibility when a new prototype is introduced.

1.1 Purpose.

The purpose of this TOP is to provide the tester standardized testing methodologies and procedures to assess handheld detection systems in order to test the overall safety, performance, and reliability of the system. It describes activities necessary to ensure safety is designed into the system under test, and to verify detection performance meets system requirements (to detect landmines, IEDs and their components, as well as ammunition cache and unexploded ordnance).

1.2 Applicability.

This document is appropriate for hand-held detection systems that are carried in a dismounted configuration. Today, detection systems are being integrated with ground penetrating radar sensors, and cannot strictly be focused on metal detection applications. Aspects of testing detection systems with single or dual sensing capability will be introduced and addressed. It will be up to the tester to determine which subtests are applicable to the system under test, and which tests are required to meet system assessment requirements.

1.3 Limitations.

a. Various levels of engineering development and production models were considered in the development of this document. Again, it will be up to the assessment team to determine which level of testing is required.

b. This document is applicable to testing of multiple handheld detection systems working in the vicinity of each other; however, testing of multiple detection systems working in cooperation is not addressed in this document.

1.4 Introduction to Dismounted Hand-Held Detection Systems and Modern Warfare Threats.

a. With the onset of IEDs, detectors have had to expand target sets from the typical conventional buried landmine to IEDs (and their components), command fire wires, hidden ammunition cache, and unexploded ordnance. Having dual sensor detection systems allows the user more ability (capability) to locate the threat. However, not all applications require dual sensor requirements. Common metal detection systems are still in high demand. They are typically lighter weight, easier to operate, and cost less than their dual sensor counterpart. Bottom line, it is up to the application and operator to understand and know the detector to fully take advantage of its capabilities.

b. The known or suspected use of landmines or IEDs by an enemy threat in ground warfare necessitates some action to neutralize or reduce the threat when new terrain is to be traveled or occupied by friendly forces. Anti-personnel and anti-vehicle explosive devices are produced in a variety of sizes, shapes, and operational design, and constantly changing in overall configuration. These threats are constructed of metallic and non-metallic materiel. They are usually buried, or otherwise concealed in roads, trails, paths, concrete curbs, culverts, etc., in areas likely to be traversed by friendly troops, civilians, or vehicles.

c. Technology has simplified the design of detection systems causing a reduction in size and weight, allowing faster processing speeds, and more enhanced algorithms in the end goal to increase detection performance, and reduced false alarms. But once again, it is up to the operator to determine target versus false alarms caused by ground and natural clutter. The operator must be fully trained on the system being tested and know and understand the various sensitivity levels of the detector functionality.

2. FACILITIES AND INSTRUMENTATION

2.1 Test Facilities.

2.1.1 Sensor Experimentation Facility.

a. This type of test facility is designed to provide for performance characterization under highly controlled conditions of soil, soil moisture content, light conditions, and/or temperature conditions. Soils are normally homogeneous, pristine soils (sand, clay, loam, etc.). Homogenous soil samples, chemically and physically well characterized, typically have well defined electromagnetic (EM) properties (electrical permittivity and conductivity, magnetic permeability, etc.).

b. This type of facility is normally used for prototype concepts. **NOTE**: Sensor Verification trials or system performance trails are discussed later in this document. Within this environmentally controlled facility, it is of most utility when applied to multiple candidates to characterize limits of (or to bench mark) performance. The facility may have integrated robotics to move detector heads at controlled velocities, directions, tilt, and height to evaluate the effects of these conditions independent of human operator, especially for each set of environmental

conditions. Cartesian gantries (x,y,z) may be used to provide a controlled method of maintaining these vectors and scalar parameters.

c. Care should be taken to ensure that the sizing and construction of this type of facility does not compromise test results. That is, certain types of sensors may be extremely sensitive to either facility (soil bin), size (height, width, and depth), or construction material. Depending upon the type of sensors, edge effects may occur at the sides of the soil bin, limiting the useable scan area. Additionally, for certain type of sensors, inadequate depths may induce unwanted or spurious reflections. If devices such as Cartesian gantries are used, nonmetallic or other suitable materials should be used for the carriage, to ensure results are not compromised.

2.1.2 Calibration/Data Collection Detection Test Ranges.

As a test control and an aid in diagnostics of detector technology development and qualification, it is recommended that special calibration and data collection areas/lanes containing buried targets be established and dedicated for detector calibration, training, engineering development, and/or verifying functionality of the detection equipment. During hardware and algorithm development, data collection activities allow maturity growth of the detection system over areas that can be repeated over and over to allow performance comparison. Typically, the buried target locations are known to the detector operators (e.g., marks on ground, target map, grid, etc.). These calibration/data collection areas allow informal assessment without comprising the formal evaluation test area where targets are unknown to the operators (e.g., “blind” test areas/lanes). (Note: the blind test areas/lanes should have restricted access until a full performance evaluation is required.) The targets buried in these lanes would be similar to targets buried in the blind evaluation test areas/lanes.

2.1.3 Performance Detection Test Range.

The Performance Detection Test Range should be representative of the environmental categories and conditions that the detection equipment is intended to be used in. Two basic approaches are suggested for selection of detection test areas: a global classification approach and a simplified approach. In the global approach, a list of typical soils found in areas of hostile territories is developed and simulated conditions should be established. These soils should be prioritized by independent experts in terms of probability of encounter or percentage of occurrence. The soils should then be grouped by similar physical properties using a soil classification method. Once accomplished, detection test areas should be selected that represent the highest probability of encounter (nominal) with possible off-nominal conditions selected, if time permits. In the simplified approach, a narrow set of soils (e.g., sand, loam, and clay) should be selected that represent the expected boundary conditions of performance for a specific sensor from worst to best, or the use of existing soil configurations, but in specific environmental considerations (e.g., arctic frozen tundra, tropics wet rainforests, or hot dry desert, sandy beaches, loamy farmland, etc.). However, using specific environmental areas are considered advanced testing because it introduces challenges associated with the soil conditions containing more uncontrollable variables (e.g., defrosted and frozen ground, water/rain saturated soils, vegetation and rodent cavities, etc.). Appendix C shows an example of the profiling process for soils. These “Blind”

lanes/areas have buried targets that are unknown to the operator or detection team. The ground truth is maintained as sensitive and used for scoring the detector performance of detection.

2.2 Instrumentation.

a. Instrumentation requirements must be considered when testing a dismounted hand-held detection system. Handheld detection systems may have data logger or computer interfaces to monitor or capture waveform or digital data responses over targets, while the detector is scanning the test area. This information also can be used to validate system models and allow for test repeatability that would not normally be available without this information. Data instrumentation packages used must be able to pull information from the detection system without causing a power drain or create an additional heat source which may affect reliability or performance. Typically, this instrumentation integration must be done by the manufacturer to minimize any interface problems to permit this parallel data capture.

b. Time and Position Tracking Instrumentation may be used on top of the detector head and on the operator to determine the path of sensor/operator over target area. The information recorded permits analysis of how the operator works the sensor over target area to validate the head passes over potential targets. If an operator is not scanning over test areas, additional training of scanning techniques must be implemented.

c. All instrumentation used should be documented in the test plan and final report, and the description of the instrumentation should include the accuracy or permissible measurement uncertainty of the instrumentation. Photographs of the instrumentation configuration and usage should be included in the final report.

2.3 Standardized Detection Targets.

Targets should consist of a common target set to allow standardization (to allow target duplication) between test targets within the test range and other test sites. Main charges, boosters, and detonator metallic material should be included in each target to ensure realistic detection characteristics. If components are not included, or substituted with another material, ground penetrating radar (GPR) signals may not reflect accurate responses. Examples of detection targets in the test lanes/areas could include, but are not limited to, the following:

a. Anti-tank landmines, metallic and low metallic: examples such as M15, TM62-P3, VS-1.6, VS-2.2, and M19.

b. Anti-personnel landmines, metallic and low metallic: examples such as M14, TS50, VS50, PMN, PMN-2, and PMA-3.

c. IED targets: examples such as plastic jug (non-metallic), sand filled pressure cooker (metallic), 155-millimeter (mm) projectiles, and 120-mm mortars.

d. IED Triggering Devices: examples such as low metallic pressure plates (carbon core, tire), non-metallic pressure plates (e.g., wood double plunger), dual conductor lamp cord, and single conductor enamel coated copper wire.

e. Clutter: natural ground clutter pre-existing in test areas/lanes (rocks, wood, roots, wash beds, and rodent holes.)

f. Man-Made Clutter: examples, such as, nails, nuts, bolts, plastic bottles, aluminum cans, and rope.

2.4 Test Controls.

a. An existing detection test facility should be used when possible. It is necessary to consider all types of climatic and environmental conditions in a great variety of soil types, so several test ranges may be considered for a thorough assessment of a detection system. These test areas should be monitored for air and ground temperatures, and soil moisture content. The test areas/lanes should have soil characteristics/profiles mapped and documented and available for detector algorithm development. The tester should consider the effects of operating on improved ground/road conditions and undisturbed terrain, with the possibility to operate in and around natural and man-made obstacles (e.g., chain link or barbed wire fences, brick or adobe walls, wash beds (wadis), trees or shrubbery, etc.). Other natural and man-made conditions may consist of snow, mud, saturated wet soils, rocky grounds, and asphalt versus gravel versus dirt roadways.

b. The tester should also consider the effects of high and low temperature extremes, humidity, snow, freezing rain, sand, dust, vibration, and electromagnetic interference. These are subtests typically performed in climatic chambers or specialized test facilities to assess durability, reliability, and electromagnetic compatibility/interoperability of the system under test. Sometimes during, but usually after being subjected to a test, functional checkouts are performed to assess system operations and performance.

c. Handheld detection systems should be tested in facilities where there are no other experimental systems under test (e.g., ground penetrating or forward looking radar system, telemetry data transfer system, remote control robotics operations, etc.).

3. REQUIRED TEST CONDITIONS.

3.1 Test Item Configuration.

In general, the item should be tested at system level, and as the latest model version or production ready, unless it can be shown that system integrity does not contribute to the specific results.

a. Specially instrumented subsystems may be included to provide a real-time record of detection trials. As an example, time and position sensors can be attached or embedded by design as special test instrumentation to provide integrated reporting of detection alerts or marks

as a function of time and geodetic position (Global Positioning System (GPS) coordinates). Instrumented systems or subsystems should be used to enhance quality assurance, in-test inspections, failure analysis or diagnostics, and data acquisition, where it can be shown that results are not compromised or that results are better quantified (area of coverage). Care should be taken to ensure that integral instrumentation is sufficiently rugged to withstand and operate following natural and induced environments. Additionally, care should be taken to ensure that the presence of instrumentation does not interfere with the man-machine interface or bias human factors appraisals.

b. The Program Manager and/or Materiel Developer should identify and provide the detector systems to the test center in advance to allow a proper initial inspection and training period prior to the start of record detection tests. Also included in the delivery, should be all the necessary power supplies (batteries) and chargers, unless prior coordination has been performed to allow the test center to procure or obtain the necessary support items in advance.

c. Technical/Operator manuals (TM/OM) must be provided with the items under test. For either published or draft manuals, the test center must review the material for accuracy of procedures and to ensure the safety and warnings are adequate to inform the operator, as well as, to protect the operator and test personnel from possible safety issues.

3.2 Test Planning.

a. Test planning should be initiated early in the acquisition process in order to yield the most cost effective approach to decision risk mitigation. Material developer should consider software, component, and subsystem level testing throughout the early development of the detection system. Each version must demonstrate effective support/operation of the system. The level of testing should be carefully considered (e.g., data collection versus blind evaluated testing). At some point, the design and algorithm must be set to progress to system level performance assessment testing in blind test areas/lanes.

b. Testing should be conducted to demonstrate that the logistics supportability is adequate. Issues in the areas of operator maintenance, transportation and handling protection, storage, and technical/operators manuals must be addressed along with availability, accuracy, and comprehensibility.

c. Test plan document should address the following:

(1) Purpose/Scope of testing.

(2) Test objectives.

(3) Test criteria (if being evaluated).

(4) Test method/procedures.

(5) Data required.

(6) Data analysis techniques for detection scoring.

NOTE: Scoring results and data elements should be addressed during all aspects of testing: Probability of Detection, false alarm rate, and advance rate, as well as, reliability, availability, and maintainability (RAM) assessment factors, Human Factors Engineering considerations, and safety overview monitoring. The classification levels of the raw, processed, and scored data (e.g., performance of detection), should be identified and recognized by all parties – Item/Program Manager, testers, and security personnel – and properly documented prior to the start of any data acquisition testing phases. This will prevent possible misinterpretation of data by new personnel not familiar with scoring practices which may cause security concerns during post test assessments.

d. Criteria for each subtest topic will be defined based on applicable contractual specifications and military requirements documents. Where the user criteria are not clearly specified, the tester must develop criteria from the relevant ITOP, TOP, MIL-STD, STANAG, contractual requirements, military specifications, or customer test plans. Development of criteria should consider the logistics concept, deployment Concept of Operations (ConOps), intended application, novel technologies, and threat environment, as appropriate. Failures and successes should be defined to provide for a clear understanding of relevant conclusions for certain subtest data topics (i.e., reliability, performance, climatic suitability, electromagnetic interference, and safety).

e. The testers must establish data requirements and analytical techniques necessary to address objectives, criteria, and performance, and to identify which data requirements will be satisfied through physical test. Test personnel should design data and check sheets for each subtest data topic.

f. Appropriate test procedures for each subtest topic relative to objectives, criteria, and data requirements should be selected. These proposed procedures should be discussed with customer, operators, and subject matter experts to ensure adequate or correct techniques are used. Detailed procedures then can be drafted and outlined in the test plan and/or Standard Operation Procedures (SOP).

g. As a tool to audit, change, or summarize the test program, it is desirable to layout all events and data requirements in matrix format. Multiple matrices, each of which may be linked, may be required and would best be displayed in a flow chart matrix. Identify any unique resources necessary to conduct subtests.

h. The item developer should identify how modeling and simulation will be used to answer test objectives which should be outlined within the detailed test plan.

i. Example of the test team man-power requirements for test execution and supporting personnel are outlined below:

(1) Test Director (a.k.a., tester). Generates the test plan, prepares test lanes, coordinates the support personnel requirements, assists with the development of the test matrix, executes the test, manages the matrix for execution, and writes the test report and any other follow-on supporting reports or safety documentation. The tester may also serve at the Range Safety Officer.

(2) Data Analyst. Develops the matrix, receives the data, controls the ground truth, and manages, analyzes, and scores detection data. The matrix must be based on number of target type encounters, per each burial depth, per each soil configuration. The quantity of encounters example for a statistical confidence achievement, based on the number of encounters, are shown in Table 1.

TABLE 1. SAMPLE OF THE STATISTICAL CONFIDENCE EQUIVALENCY BY THE NUMBER OF TARGET ENCOUNTERS.

PERCENT STATISTICAL CONFIDENCE	NUMBER OF ENCOUNTERS AT THE SAME PARAMETERS[a] FOR EACH TARGET TYPE
90 %	30
87 %	27
83 %	21
80 %	18
[a]Test Parameters: depth, soil type, operator	

(3) Data Collectors. Monitor and track performance and operational parameters of the detector system (e.g., times, operators, SUT), assist in the placement of alarm markers along detection routes, and generate log books and incident reports. The Data Collector may also record operator observations and comments while scanning lanes with detectors under test. This also includes monitoring the maintenance personnel that perform repairs or software updates to record into log books.

(4) System Operators. Operate the detection systems under test, scan the target areas, indicate whether the target is a valid target or possible false alarm, identify where alarm markers are placed on the lane to detail the location of a target, provide feedback on the operation of the detector systems, and complete human factors surveys.

(5) Geodetic Surveyors: Operate the GPS survey equipment, and survey alarm marker positions providing the data (e.g., detector alarm files of possible target locations) to data analysts for scoring.

(6) Test Support Personnel: Prepare the lanes to remove all visual cues of target locations, assist with alarm marker placement and/or removal, and after scanning of each lane, to remove visual cues of operators and data collector's foot prints (e.g., raking, dragging the lane, etc.), and other duties as needed to keep lanes ready for operators to scan the test lanes.

3.3 Factors and Conditions for Performance Testing.

The cumulative test results, together with the results of appropriate engineering and data collection tests, will allow an estimate to be made of the degree and readiness to which the design requirements of the detection system has been met, and the suitability of the system to meeting operational need. The conceptual test assessment should cover the following areas of concern:

a. Sensitivity. The object is to obtain a measure of the overall system's ability to detect targets by providing the operator a reliable notification (alarm) of when a possible target is within detection parameters. The sensitivity assessment provides the ability of the detection system to detect metallic and non-metallic targets as a function of the search head's height about the surface and/or the depth of the target below the surface. Controlled calibration or data collection lanes typically support this type of assessment.

b. Mutual Interference. The objective is to determine the minimum non-interference distance between two operating detection systems and/or with other fielded detection systems. Operate two matching or other detector type adjacent to each other and determine minimum distance before operational interference. Compatibility and susceptibility assessments with other tactical RF systems (e.g., radios, radar systems, counter remote control improvised explosive devices (RCIED) electronic warfare (CREW) systems, etc.) are vital to the ability of the detector under test to be integrated in today's RF combat environment.

c. Human Factors. The objective is to determine the detector's stability with operator's handling of the system, how detection system notifies the operator (e.g., audibly or visually), and whether fatigue plays a factor during required mission operational time profile.

d. Performance. The objective is to obtain a measure of the detector's ability to perform its intended function in simulated mission situations. The measure of ability is determined by Probability of Detection (Pd), False Alarm Rate (FA), and Advance Rate (AR).

e. Environmental. The objective is to determine ability of the detector to operate effectively during and after it has been subjected to extreme environmental and logistic transportability conditions (transportation vibration, rough handling, climatic, and situational (e.g., rain, immersion, salt fog, fungus, altitude, high and low temperatures, etc.)).

3.3.1 Test Variables.

a. Testing shall be designed to collect system performance data over a variety of ground/terrain/soil conditions, time-of-day considerations, and with various standardized threat and clutter targets. To the extent possible, the trials will be controlled and executed such that the systems' performances are directly comparable to baseline systems to be replaced or competing systems. Since climate cannot be controlled at outdoor test ranges, the tester must consider how data between test samples at different sites/locations, time of day, or time of year can be compared effectively. The tests will be conducted with data element considerations outlined in

Table 2. It is recommended to benchmark developmental and competing systems concurrently over same lanes, same targets, and same environmental conditions with a rotation of operators.

TABLE 2. MATRIX OF TRIAL FACTORS, CONTROLS, AND CONDITIONS

FACTORS	CONTROLS	CONDITIONS
Threat Target Type (ITOP 04-2-521[1*])	Standardized Repeatable Targets (unclassified), Current Threats, Availability, Authentic Components	Actual; downloaded, simulated, surrogate target types.
Target Layout	Current Intelligence, Common Test Practices, Doctrine Configuration	Replicate burial depth, surface preparation; emplacement techniques; stacking and/or cluster techniques, target proximity to clutter, fill techniques, orientation, depth measurement techniques.
Detection Lanes	Prepared Test Lanes, Various Soil Media Types (Homogenous and Native); Moisture Content Management	Homogenous soil media: loam, sand, gravel, mix material; to include grass vegetation, loose and compacted ground, virgin ground, controlled wash beds. Allow for a calibration to be available for each type of background condition. Native soils need characteristic soil profiles data established.
Time-Of-Day	Diurnal cycle spans all conditions of solar radiation and thermal input	Dividing diurnal cycles into defined intervals (e.g., Daytime (1000-1800 hrs); Evening (1800-2200 hrs); Night (2200-0600 hrs); and Morning (0600-1000 hrs)).
Climate	Ensure that various test sites are established or identified that provide full range of climates. Test in those conditions required in requirements document.	Use STANAG 4370[2] to characterize climatic conditions for specific test sites. Select test sites based upon range of conditions: arid, tropical, frozen, moderate, etc. use standardized target sets at all sites selected for specific trial phases.
Human Participants	Common scanning techniques; training skilled operators.	Primary choice - select test participants with the correct or associated military skills for operating detection systems to include both male and female personnel wearing a full complement of required clothing and equipment. Secondary choice: civilians that are trained to a common standard for target detection to include both male and female personnel wearing a full complement of required clothing and equipment.
Detection System	Existing Baseline	Compare to existing system to be replaced or competitor(s) to provide baseline reference (i.e., better than, etc). Ensure that sufficient sample size is available to be a production representative sample or a statistically relevant population. Have sufficient spares or on-site field service representatives for repairs to prevent test delays. Maintaining adequate power supplies (e.g., batteries) to ensure continuous scanning operations.

*Superscript numbers correspond to Appendix J, References.

TABLE 2. CONTINUED

FACTORS	CONTROLS	CONDITIONS
Environmental Simulation Tests	Climatic Chamber Tests	Test to the specific environments identified as mission essential requirements (e.g., sand/dust, hot, cold, rain, salt fog, humidity, logistic handling, etc.).

b. A matrix of conditions should be established with a finite number of threat and clutter encounters planned for each condition (e.g., at each depth, in each soil, for each target type, etc.). The total number of trials will drive the duration of test. Therefore, it is incumbent upon the test planner to limit the test conditions to a period in which all parameters can be practically addressed. The test planner should ensure that for each human participant/system combination, a corresponding minimum number of repetitions of background, system type, performance test area, etc., occur to provide a statistically relevant set of system performance trials. See Table 3 for examples of test variables to aid in developing trials to enable assessment in a various range of factors and conditions, or a specific performance characteristic interest.

TABLE 3. EXAMPLES OF TEST VARIABLES

ELEMENT	CONTROL FACTORS	VARIABLE CONDITIONS
Detection Test Lane	Tactically Varied	Improved, native (in-situ), simulated (shipped in gravel, sand, and topsoil material), straight, curved, dips, and hills
Target Type	Systematically Varied	Antitank/antipersonnel mines, Improvised Explosive Devices main charges , and trigger components, and clutter. Metallic, low metallic, or no metallic contents, foreign and domestic, explosives or simulant.
Target Placement	Systematically Varied	Depth buried, configuration, compaction, multiple targets, etc.
Soil Type	Semi-Controlled	Loam, sand, gravel, desert silt, roadway beds, compacted soil material
Climatic Conditions	Systematically selected but uncontrolled	Standardized Climatic Categories[b] (e.g., A1, B2, C1, etc.).
Light Conditions[a]	Systematically varied, if necessary	Dawn, Day, Twilight
Operational Status	Uncontrolled	Switching of arms; taking interim breaks during detection run

[a] Night operations are not typical and detection systems may not incorporate night visual capabilities other than the use of external support equipment (e.g., flashlights, night vision optics, etc.).

[b] Climate Categories (MIL-STD 810G[3]): A1 - Hot-Dry Climate, B2 - Variable High Humidity, C1 - Basic Cold

3.3.2 Other Considerations.

a. Special Test Considerations.

(1) Operators. The operators must be identified early in the planning stage to whether they are required to be military and/or civilians, and where will they come from (e.g., customer provided, test range selection, etc.). If military personnel are required, ensure a Test Schedule and Review Committee (TSARC) request is submitted within one year from the start of testing or as early as possible. A Safety Release (SR) must be obtained from the U.S. Army Evaluation Center (AEC) prior to using military personnel as test participants. The SR indicates a system is safe for use and maintenance and describes the specific hazards of the system, operational limits, and required precautions (see Department of the Army Pamphlet (DA PAM) 73-1[4]). If military operators are not available, or SUT quantity exceeds required number of operators, civilian operators (range support civilian personnel) are often used to supplement the required number of operators. It is preferred that skilled personnel with mine sweeping training be primary candidates, but not necessary. All personnel will be undergo a training period prior to testing to ensure there are common scanning techniques, and the testing methodology is standardized for all operators. To ensure a full spectrum of possible operators, operators should include both male and female participants wearing a full complement of required clothing and equipment.

(2) Special Test Controls. There may be special test controls added to ensure that operators use detection equipment under operationally realistic conditions. Since it may not be practical or exceedingly costly to build numerous test lanes with actual threat targets, it may be necessary to design the test so that operators do not “learn or game” the test lanes. Test controls should include: training; pilot tests or trials in the Sensor Verification Area (e.g., data collection area); rotation of test operators; changes in directions, times of day (see Table 1), deliberate false sets of targets, varying “weathering in” of targets, and if possible, varied vegetation and soil conditions.

b. Safety Documentation.

(1) Safety Assessment Report (SAR). Safety documentation on the system under test is obtained from the materiel developer’s safety team. The SAR is a formal, comprehensive safety report that summarizes the safety data that has been collected and assessed for the life cycle of an item. It expresses the considered judgment of the contractor or developing agency regarding the hazard potential of the item and any actions or precautions that are recommended to minimize these hazards and to reduce the exposure of personnel and equipment to them. Material Safety Data Sheets (MSDS) must be provided for the batteries and any other hazardous material.

(2) Preliminary Hazard Assessment (PHA). Broad hazard-screening tool that includes a review of the handling and operation using the system under test, and identifies the hazards associated with the operations on the test range. The results of the PHA are used to determine the need for additional, more detailed hazard analysis, serve as a precursor documenting that further analysis is deemed necessary, and serve as a baseline hazard analysis where further analysis is not indicated.

(3) Safety Confirmation indicates if specific safety requirements are met, includes a risk assessment for hazards not adequately controlled, lists technical or operational limitations or precautions, and highlights safety problems that require further investigation. The Safety Confirmation is required to permit the system for tactical deployment.

(4) Technical/Operators Manuals contains the manufacturer's procedures, as well as, the cautions and warnings when handling and operating the SUT.

(5) Range Standard Operating Procedures from test range reviews of the system, listing hazard mitigating steps for the operator of the SUT and test personnel.

c. Training.

(1) Training is required to orientate operators with the system(s) under test and proper scanning techniques. Training also includes communication orientation between operators and data acquisition personnel to develop the verbal link from operator to data collection personnel for documenting operational activities. Assure that the proper training for the operation of the system is provided to the testers, operators, and if necessary, the data collectors. It is imperative that the emergency shutdown procedures are emphasized in this training, which could be no more than the OFF switch. An operator must be well trained in what to do should a problem occur and/or if a problem is reoccurring. Operators and test team training must always be the lead-in activity.

(2) Following training, a pilot test should be performed to ensure operator and test team familiarity with the SUT and test methodology, which may include performing a number of practice detection scans on calibration/data collection lanes. Proper scanning techniques and coverage procedures should be stressed during this training and pilot period. Pilot tests will also serve to familiarize detector operators and test observers (data collectors) with the data collection and reporting procedures to be employed during system performance trials.

NOTE: Performance of Detection tests are those trials where data will be used towards assessing the effectiveness of system detection performance, or for other evaluation purposes relative to the suitability of the detection system. Tests should not begin until each team member has demonstrated competence. Test team rotation is intended to ensure that lower or higher performing individuals do not bias performance results. Deliberate false sets of targets (clutter) should be introduced to include empty holes, surface disturbances, or rural and battlefield debris. Weathering in of targets enables proper testing of the detection equipment, to include removing visual cues that provide the operator(s) a secondary opportunity to locate the buried targets. Counter Measure (CM) equipment may have to perform after the targets have been weathered in place for 1 day to 1 month. Demining equipment may have to perform after the targets have been weathered in place for 1 month or much greater. Pre-test dragging of test areas/lanes may eliminate soil settling issues around buried target locations.

d. Operators interaction with data collectors. Communication between operator and data collectors during detection trials must be refined prior to the start of formal testing. Time data

(e.g., detector operational duration, battery usage time, mission time, etc.) must be collected during testing, and typically a good time to practice communication between operator and data collector is during training/orientation periods. Information that must be collected by data collectors during testing, but not limited to, include: when batteries are changed, when detectors are switched OFF/ON, when detection alarms are activated, confidence level of operator related to actual target detection (false alarm, or not), and any other anomalies while performing the detection mission on the test lanes. The operator must constantly verbalize information to the data collector who is documenting what is being declared in test log books.

e. System Tracking/Monitoring Database. Prior to the start of testing, data tracking recording methods on the system under test may be established. The test team must monitor the system as a whole, as well as individual components and support systems (e.g., batteries, straps, etc.). Proper titles/names of components must be obtained and verified with materiel developer/contractor to be compatible with technical/operational manuals. Data elements must be outlined with specific units identified in test plans. Performance parameters and scoring criteria should be identified to assist in the documentation to reflect preliminary success or limitations experienced during testing. Also, failures or discrepancies of test items are documented in the tracking/monitoring database to assist in reliability assessment.

3.4 Frequency Allocation.

a. The tester is responsible for requesting radio frequency (RF) assignments from the local spectrum frequency manager in the proposed area of testing. Dates required for the entire test period, plus a contingency period if testing delays are experienced, should be included in the request. The local Spectrum Management Office (SMO) receiving the frequency assignment application (DD1494 form and or J5) will process it through established channels to request appropriate national and local approvals. The disposition of the frequency assignment request will be channeled back to the tester. The request may be approved, disapproved in total, or approved in part with operating limitations (notching out specific frequencies). Typically, frequency approval takes about 50 days, but resolving conflicts can take up to six months lead time, so this information must be requested and submitted as early as possible. Appendix A lists the information needed to submit a request on the DD1494 form.

b. This RF information must be provided by the test proponent no less than eight weeks prior to the start of testing in order to ensure approvals are obtained to meet the desired test schedule. This information must be provided for each transmitter and receiver of a particular system being used for test and in support of testing (fielded unit used for comparison).

3.5 Other Supporting Documents.

a. Performance/requirements specifications contain complete design and operational specifications for the system requirements. It includes the series of targets that the SUT is required to detect, and what the mission role of the intended operating units, as well as other users' need for the system. In addition to operational/functional requirements, the performance/requirement specifications should also contain nonfunctional (or supplementary)

requirements which impose constraints on the design (such as quality standards and design constraints).

b. Capabilities Requirements/Operational Requirements Document. Describes the overall mission, the type of system proposed and the anticipated operational concepts in sufficient detail for program and logistics support planning, and includes a brief summary of the mission need. This type of document would include criteria that the system must meet.

c. Security Classification Guide (Required Document). Classification guidance issued by an original classification authority that identifies the elements of information regarding a specific subject that must be classified and establishes the level and duration of classification for each such element. See Appendix H for example definitions of classified versus For Official Use Only (FOUO)/Unclassified data elements that must be agreed upon and concurred by all parties (e.g., item/program manager, materiel developer, testers, security etc.) prior to the start of testing.

d. Programmatic documents that may have been developed for the system, or those pre-existing documents that apply, should be used to identify test criteria and determine test limitations and safety hazards that may exist. These documents may define the mission scenarios, climatic conditions, operational, and electromagnetic environments in which the item must operate. In some cases, it may define the test center which relates to the type of environmental background the test must be executed in. Documents that should be used to establish test criteria include:

(1) Test and Evaluation Master Plan (TEMP).

(2) Test Directives.

(3) Military Regulations, Standards and other controlling directives.

(4) Federal/State Statutes and Environmental Laws.

(5) Military Field Manuals.

(6) Material Handling Data Sheets.

4. TEST PROCEDURES.

4.1 Receiving/Initial Inspections.

Inspections will be used as test controls/baseline conditions to assure readiness of SUT and to reduce decision risk where sample sizes are limited.

a. The SUT will be inspected prior to the commencement of testing. The initial inspections will establish the status of the SUT and supporting test equipment prior to the start of the tests. The results will be recorded and serve as the test control. The inspection should

establish that the SUT is complete with all required operational components and software, and is in a safe working order. It is to be checked for damage, and if it conforms to specifications.

b. Initial inspections will document the packaging, nomenclature (manufacture serial numbers correlating to test center induced identifying numbers), type (if special variants are built), and quantity inventory of each type of test item. Inspections may consist of a combination of physical and non-destructive examination to determine the safety of the item and the physical condition prior to and following tests. Inspections may be augmented by other forms of electronic checks with special test instrumentation if test hardware has been designed to facilitate this type of check.

The test team must perform a characterization inspection of the detection SUT(s) and take photographs showing overview of test item(s), images at each orientation (e.g., 360 degree around), specific and unique components, accessories, cables, connectors, markings, etc. This aids in reviews and analysis of items when investigating specific areas of interest. Photograph all damage or visual discrepancies to document condition at the time of inspection. (**NOTE**: testers can never have too many pictures or views of a test item.) It is recommended to take photographs of test item in isolated view (no other objects in view frame), all orientations, and with operator(s) in control of test item (in all human/machine interface configurations). This provides a resource of images to pick from or assess during follow-on test operations or reporting activity. It also provides a visual description of operator/hardware integration, as well as assessing for human factors engineering and safety.

c. Technical/Operator Manuals (TM/OM). Obtain the latest version of the manual. Document what version is provided (edition and date). TM/OM is reviewed to ensure it addresses the specific configuration of hardware and software under test, and the accuracy of information provided. The TM/OM must be reviewed for safety warning, hazards, precautions, and operational procedures. Document any discrepancies with test agency and materiel developer. All safety or operational discrepancies should be reviewed with materiel developer prior to test hardware activation or start of test operations, depending on the severity of discrepancy.

d. Perform a safety inspection by a qualified safety engineer or test officer to identify potential safety and health hazards on the SUT prior to the start of functional operations. Induce safety mitigations, if necessary, to prevent hazards to operator.

e. Preventative Maintenance or Assembly Requirements. If applicable, complete a preventive maintenance checks and services (PMCS) action in accordance with the TM/OM. Often, a Field Service Representative (FSR) (associated with materiel developer or developing contractor) must perform pre-test tasks to assemble the item(s) prior to officially handing over the test hardware for test. After the completion of the assembled hardware, perform an initial or another characterization inspection.

f. Operational Check. Test items must be powered on and operated to verify operational status at the time of receipt/inspection. Test personnel must utilize the required power source (e.g., battery, voltage, etc.) to activate the system. Electronic Built-in-Test (BIT) are performed,

sensors are activated with simulated targets (source of detector stimuli), and displays, lights, and light-emitting diodes (LEDs) are checked to verify operational status. This operational check is the baseline to demonstrate the system under test is operationally ready for test.

g. Inventory the system support package (SSP), if provided (e.g., straps, nuts and bolts, covers, etc.). Record the findings of that inventory.

h. Compliance to the test criteria should be limited to visual inspections or functional checks using procedures given in the supplied TM/OM, or instructions provided by the materiel developer's or developing contractor. Operational functionality and physical characteristics may be necessary to address whether SUT meets design and/or contractual specifications/criteria.

4.2 Physical Characteristics.

Measure and record the physical characteristic of the SUT (e.g., dimensions, weights, center of gravity, etc.). Check the data during the inspection to ensure that they meet the design and/or contractual specifications/criteria. Perform physical measurements of test items in shipping configuration, bare, folded/extended, with and with power supplies, etc.

a. Size (of complete unit or each subunit, as appropriate).

b. Weight (of complete unit or each sub-unit, as appropriate): total weight, balance distribution (human factors issue); weight of power supply (e.g., battery).

c. Volume (space utilization).

d. Detection head size and static area of coverage.

4.3 Performance.

4.3.1 General.

a. All procedures for the detection assessment apply to system performance trials. System performance trials are designed to demonstrate the detection equipment performance, as well as, the participants' respective capabilities to detect buried targets in operationally realistic conditions. Performance and reliability parameters will be developed from the system performance trials for the purposes of determining overall assessment. Other sensor verification testing activities may support source selection, performance benchmarking or investigation, diagnostics, data collections, training, or pilot and assessment trials. While these trials may yield useful parameters for the objected purposes, data should not be aggregated with the system performance trials. Ensure that trials include the baseline fielded system for comparison purposes in addition to the detection equipment candidate(s). Ensure that the baseline system is in new or like-new operational condition.

b. Performance benchmarking implies establishing a reference performance level for ideal, controlled conditions so that a range of expected performance levels and expected

degradations can be established for sets of ideal, controlled conditions. Additionally, the benchmarking can be accomplished using the system to be replaced as a special reference standard for a set of ideal, controlled conditions. While not mandatory, benchmarking can provide useful information for subsequent diagnostics, as well as enabling side-by-side comparisons with existing or competing systems in controlled conditions, especially when a standard set of targets are used.

c. Detection system testing should progress logically and systematically from the experimental through the system performance trials. Experimental and system performance trials phases need to be planned together to be synergistic and support each other. Progression through the test program should provide increasing confidence that the capabilities and limitations of the equipment under test are defined and understood.

d. The levels of performance required of the SUT should be specified by the user in the user requirements document or the equipment requirement specification. If testing for urgent fielding, the detection targets and lane characteristics should be similar to theater environmental conditions.

4.3.2 Sensor Experimentation Testing (Source Selection, Benchmarking, or Investigative Experimental Trials).

a. Prior to the start of all testing of each SUT or baseline system, ensure that no targets have been inadvertently disturbed. Record the characteristics and location of each target's positions and burial depths/orientations. Ideally, mark the target's position with non-interfering markers (e.g., nonmetallic devices - golf tees) that identify target type, location, and depth.

b. Mount the SUT detection system on a maneuverable platform above the area containing a target or maneuver using a human participant. Either through cabling, telemetry, or other conventional manual means record the output history as the candidate detection system advances over the target area. Ensure that advance rate and sensor height replicates the expected heights and advance rates. If automated means are used, record the output history as a function of soil type, target type/location, path, advance rate, height, and candidate or fielded detection system. Other variables of importance may be added.

c. Depending upon sensor outputs and signal processing/display methods, the start and stop times for each "trial" or "mission" should be recorded to establish a time history for the trial. This will also determine the advance rate if required.

d. During and/or following each trial, the location data (e.g., detection alarm) for each detection mark should be recorded and compared to each buried target location to determine if the declaration "alarm" spot would have been a detection event or false alarm. At this sensor experimental/development facility, for most candidate detection systems, false target sets or disguised target sets (clutter) are optional, and may not be of interest or desire, where focusing strictly on valid targets is the primary concern.

e. A description of the Sensor Experimentation Testing Facility should be included with the following documented conditions: soil types, soil moisture/density, test area size, buried or uncovered, natural or artificial light, ambient or artificial climate control, and other descriptors. Other soil properties may be of value for specific sensor types. If artificial light or artificial climate control is used, the range of values occurring during test should be recorded.

4.3.3 Sensor Verification Testing (Data Collection Trials).

Sensor verification testing should be done initially by special test technicians or materiel developer's subject matter experts/contractor operators upon receipt of candidate or fielded detection system(s). This testing will be performed to determine if the test items are ready for test or have been damaged as a result of shipment. After initial inspection and sensor validation the Sensor Verification Test Area will be used for training, demonstration and pilot tests (learning trials), and diagnostics (performance verification and troubleshooting software faults).

a. The sensor verification area will be set up with geodetically surveyed detection targets of all types identical to those being used during formal system performance testing. Record the geodetic surveyed plot of target positions and burial depths/orientations. Photographs should be taken of target placement prior to backfilling. The ground truth database documenting the coordinate location and target characteristics is established, maintained, and updated continuously. Prior to the start of all trials, inspections, training, or pilot test of each candidate or fielded system, the test team must ensure that no target has been inadvertently disturbed.

b. Document inspections, training, or pilot tests to assure test readiness and provide a historic tracking of developmental progress. This data (derived from standardized data sheets) would be entered into the Tracking/Monitoring database (paragraph 3.2.e). This is a good opportunity to collect upfront assessments concerning safety, human-machine interface, as well as, detection performance. It also documents the hardware readiness. Diagnostics should also be documented to provide an audit of readiness issues, factors, or recommendations that should be corrected prior to formal scoring tests or even fielding. Examples may include corrected field manuals, training packages, scanning techniques or procedures, or amending test procedures.

c. Pilot tests in the Sensor Verification/Data Collection test areas should parallel the test process and methods that will be used during formal performance tests. This will establish test execution proficiency to the entire team of test participants (test officers, operators, and representatives) and test observers (data collectors) prior to system performance trials. It also provides a rehearsal session between the test participants/operators and data collectors to adjust the collection of required data elements during the scanning and detection process, so when formal testing is executed, the data collectors are transparent to the test participants/operators without hindering their mission (e.g., operators are verbalizing information about the detector and detection performance to the data collector).

4.3.4 System Performance Trials Test Lanes/Area (Blind Performance and Scoring).

4.3.4.1 Pretest.

a. Prior to start of test, ensure that all test readiness issues have been resolved satisfactorily (e.g., detection systems are latest configuration and operational, test areas prepared and conditioned for detection scanning, operators are orientated with detection systems, etc.). Each detection test lane/area will be set up with surveyed targets of all types to meet threats that are common to existing military conflicts or terroristic activities (e.g., IED configurations for a given region of the world). However, these target representatives must be agreed upon by the acquisition assessment chairman and materiel developer and meet threat target objects (e.g., metallic, low metallic, and non-metallic target types and configurations). All targets must be surveyed during emplacement using Differential Global Positioning System (D-GPS) survey equipment with accuracy to ± 2 centimeters (cm) to obtain coordinates in Universal Transverse Mercator (UTM)-World Geodetic System (WGS)84 grid prior to burying (covering/disguising). Record the plot of mine positions and burial depths/orientations along with target identification (ID) and corresponding characteristics. A photograph of each target prior to burying aids the analysis team in target identification when any questionable issues surface about a specific target position. Ensure the test lanes/areas are spread out and separated enough to allow for multiple systems to interrogate lanes simultaneously without interfering with each other (e.g., electromagnetic interference).

b. The test lanes/area will be operationally realistic. When clutter or ground disturbances are added (false target sets, vegetation, etc.), these will be surveyed to obtain coordinates, photographed, and narrative description recorded. Each test lane/area will be assigned a unique test ID number (e.g., Lane ID). Each planned trial or mission will have a unique mission ID. Each test player will have a unique test player ID to be retained throughout testing. If teams of test players are used for a search method, the team will have a unique ID.

c. Test Schedule and Daily Events. The performance test phase must include several phases/events that are part of the overall test effort. These phases/events must be addressed and scheduled time allocated for an effective test assessment (e.g., allocating time for operator and test team system training, test methodology orientation, execution plan to accomplish the test matrix, and intermittent periods for Human Factors assessment).

(1) Training/Orientation Time. Training/orientation periods should be allocated as close to the start of the detection mission trials. Detailed training and periodic orientation/refresher training on the systems under test must be programmed for operators and test personnel, especially if rotational between different types of SUTs. Training should be geared to the lowest level of operator skills. Data collectors and test personnel may not be as advanced, and may only need a thorough overview of the system(s) under test; whereas operators need hands-on/sweep time to fully, effectively, and proficiently operate the systems under test. There may be several categories of operators: subject matter experts (SME), military experiences, and novice (beginners). Depending on the level of assessment, a mix of operator types provides an overall assessment of the system human-machine interface (e.g., ease of operation, interruption of alarm indications, scanning techniques, etc.).

(a) Training should be provided by a trainer who was formally trained by or represents the manufacturer on that specific item under test.

(b) Training is conducted on target types and detector's response to metallic and non-metallic signatures along calibration devices (positive sensor responses). This provides the control and audible functions and target determination the detector provides when activated by a valid target. Operators should be provided instruction on a calibration lane, area where targets are known: location, type, and depth. Operators will be instructed over training calibration and data collection lanes containing similar targets as blind test lanes. On training/calibration lanes, operators will be instructed on how to perform a proper scan to maintain a consistent speed and sensor height over area to be scanned, as well as, to ensure the entire lane/area is covered by the detection scanning process, as the operator progresses through the lane/area.

(c) The refresher orientation is for operators who have been trained previously on the system under test. This gives them a short review of the operator's manual, overview of detector system controls, and hands on operations.

NOTE: Using expert operators helps to insure that the detection systems are used in an optimal fashion, assuring that the essential sensor data is of high quality, and provides a measure of the higher confidence on system performance. Using independent, novice, but trained operators, provides a measure of system performance that may be similar to that of typical, trained military operators.

(2) Test Matrix. A test matrix (detailed daily schedule) must be developed for system performance missions to ensure that all combined possibilities are addressed (e.g., using all operators, detection systems, and scanning over all test lanes that contain required target encounters). This planned matrix should be outlined in the test plan. Detailed mission run specific elements (e.g., lane direction, which operator with what system, assigned data collector, etc.) are provided when the tester outlines daily mission run activities to correspond to the planned test matrix. The test duration (number of test days required) should be developed based on what the matrix timetable that can be completed in a day's work period times the number of lanes that can be scanned in one day. Contingency days must be planned for weather delays, hardware discrepancies, or any other uncontrollable or unplanned conditions or events.

4.3.4.2 Mission Detection Performance Test Phase.

The generic methodology of how the detection performance test is executed is outlined in the following paragraphs. The execution phase is divided into the following phases:

- Pre-mission briefs
- Detection/Performance missions
- Post-mission detection alarm compilation and Quality Assurance/Quality Control (QA/QC) checks
- Detection data scoring (performance analysis)
- Human Factors Operator Surveys

a. Pre-Mission Briefs. The test officer provides a test brief outlining safety issues and proposed mission matrix runs to all personnel. During the brief, the test officer identifies a mission lane assignment (Figure 1) for each operator and paired with a data collector. The lane

assignment is a unique identifier for that run. Data collectors, geodetics surveyors, and data analyst personnel use the unique lane assignment to characterize the detection results for reporting purposes. Figure 1 is an example of one method to identify a mission run. Other codes could be added as necessary.

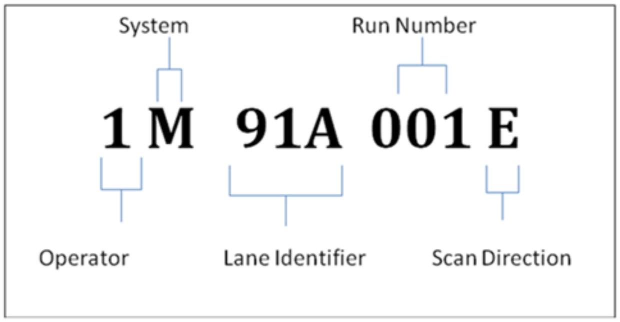

Figure 1. Example of a format for assigning test mission identification.

NOTE: Following is a description of each code in the Test Mission ID elements (figure X):

- Operator – Distinguished by the lead number. Each operator has an identifying operator number.
- System – If there are multiple systems under test, each is distinguished by using a letter code (e.g., L, M, N, O, etc.).
- Lane Identifier – Blind test lanes are distinguished by number and letter code: (e.g., 91A, 72B, 65, etc.).
- Run Number – Three digits are used for run (mission) number.
- Scan Direction – Referred to the scan direction of travel: north (N), south (S), east (E), and west (W).

b. Detection/Performance Missions Events.

(1) System Calibration/Ground Balancing. At the start of each test day, perform the startup and operational procedures per OM or manufacturer provided procedures. Power up the detection system. Warm up and calibrate systems in accordance with (IAW) startup procedures and calibration detection pieces. Document any failures found by the BIT or other means, or any failure of the BIT itself, including false BIT indications. For pre-and post-mission checkouts, perform a BIT before and after each mission. Record the results on a daily data log sheet.

(2) System performance detection missions. The basic detection mission consists of target encounters over a test lane/area with the detection system under a specified set of test conditions. A system performance mission (scanning one lane) will provide a finite number of planned target encounters for each path/direction and target type through the test lane/area. Testing should be limited to a specific number of days and encounters. Planned target encounters must be executed within this time period because additional days may not be available (e.g., personnel and equipment availability). Total test days must ensure target types

meet the minimum number of engagements (encounters) to support the specifications or confidence/probability goals.

(3) Scoring lane runs. Sufficient time must be allocated daily to survey the completed mission/performance runs. Alarm target markers should not be left un-surveyed overnight. Data needs to be collected and recorded by day's end. Preliminary scoring of performance should be achieved on a semi-real time bases. However, adequate number of days must be allocated to process and final performance data.

(4) Data reports may be required for both classified and unclassified levels of information. Time must be allocated in the overall schedule to sequential draft and publish two separate documents if required.

c. Following each day's daily planning session outlining test requirements, matrices, and goals, the test team will move out to the test lanes for performance testing. The test officer assigns each operator/system a blind test lane to perform a detection mission run. Sequence of activities is as follows:

(1) At the start of each test day, the operator and data collector will acquire a new set of or freshly charged batteries to install into the detector. The operators will turn on detection systems at the beginning of each test lane, and perform startup ground balancing and calibration procedures. Depending on assessment for reliability, the systems will be turned off or left on between detection runs.

(2) Record battery usage times, lane sweep start and stop times, and other mission information for each detection area to be swept. An example of a Mission Field Data Collection form is provided in Appendix D. The form would be completed by data collectors (or equivalent) that are assigned to follow the detector operator during performance detection activities.

NOTE: Execution of Performance testing is on clean lanes without target markers or visual cues (e.g., wires, burial spots, target exposures, accumulation of footprints, accumulation of gravel or ground material from raking ground area, etc.). Test team must ensure these visual cues are removed before any test runs. Typically, the lanes are cleared and dragged at the end of a detection scan.

NOTE: Most human operators will deliberately or unwittingly venture to locate and identify targets for follow on detection runs. To prevent the test participants from being cued by prior knowledge for these sequential detection runs, special test controls should be adhered to and controlled by the test director (e.g., dragging lanes, removing debris or rocks landmarks on side of lanes, having operators run in opposite directions, rotation of operators, etc.).

(3) Per the planned test matrix, perform detection mission scenarios scanning the entire designated test lane by traversing each blind test lane sweeping forward and back until the desired length and width are covered by the scanning process. Each operator will sweep the designated area/lane and indicate where an alarm marker is to be placed (e.g., in direct response

to detection system alarm indicator). The operator will mark all suspected locations indicated by the detector's audible and/or visible alarm designator. An alarm marker (e.g., plastic poker chip or equivalent) should be placed on the spot where the operator determines the detection system is providing the most confident indication of a possible target's location. Some assessment teams may use different color markers to identify high confidence detection location alarms and another marker for low confidence or suspected clutter positions; however, this assessment is highly operator subjective in nature.

NOTE: Detection mission runs are performed to accumulate the required number of target encounters distributed over the blind test areas/lanes established for this test. In the matrix mission run development, the goal is to obtain equal number of encounters for all target types.

(4) This detailed process of the detector system moving down the lane, the operator or a data collector puts down detection alarm markers (e.g., numbered poker chips) where the system detects and the operator declares a potential threat target. This event will leave a trail of poker chips down the lane. The test support personnel will follow taking inventory of the alarm markers. The numbered markers (poker chip) are recorded on the data sheet (see Appendix D for a sample data sheet).

d. Post Mission Quality Checks.

(1) At the completion of scanning the lane, the data collector confirms the data sheet count of poker chips to the last numbered poker chip marker on the lane. The number of recorded detection events and number of poker chip alarm markers should match. This quality check of alarm marker count is verified again by comparing the number of surveyed alarm poker chip markers when the surveyor locates each chip on the lane to establish coordinates for each spot.

(2) The alarm marker poker chips are surveyed by a survey team using DGPS survey equipment to obtain the coordinate array (e.g., WGS UTM84, Northing and Easting) for each alarm marker (poker chip) position (see Figure 2). The surveyor will locate each poker chip on that specific lane, identifying it by the number on the chip. After the completion of surveying all the placed chips of a given mission run, that surveyed chip count is compared to the number of marker chips dropped by the data collector during the scanning process. This second quality check verifies all chips have been accounted for and have been surveyed, and validates the mission run by the test officer ensuring a QA check confirms by three separate sources: data sheet count, actual poker chip count, and number of surveyed marker chips. If all three confirm, that mission run is complete. If the count is a mismatch, an investigation is performed by reviewing data sheet, counting poker chip alarm markers, and reviewing the surveyed ID numbers. A solution is concluded prior to any movement of chips.

NOTE: The above process simplifies the mission run preparation, scanning, marking, and identifying alarm markers for scoring. It does not address any operational or detection issues during mission runs. Scenarios may vary; therefore, standardized corrective action procedures cannot be determined at this time. The hardware TM/OM must be reviewed to determine any actions required for system to operate proficiently; if no corrective actions or procedures are

identified, the test team may make decisional corrective actions to get system to an operational status. All events, malfunctions, fixes, solutions, and required times to fix issue, is documented in test logs and final report.

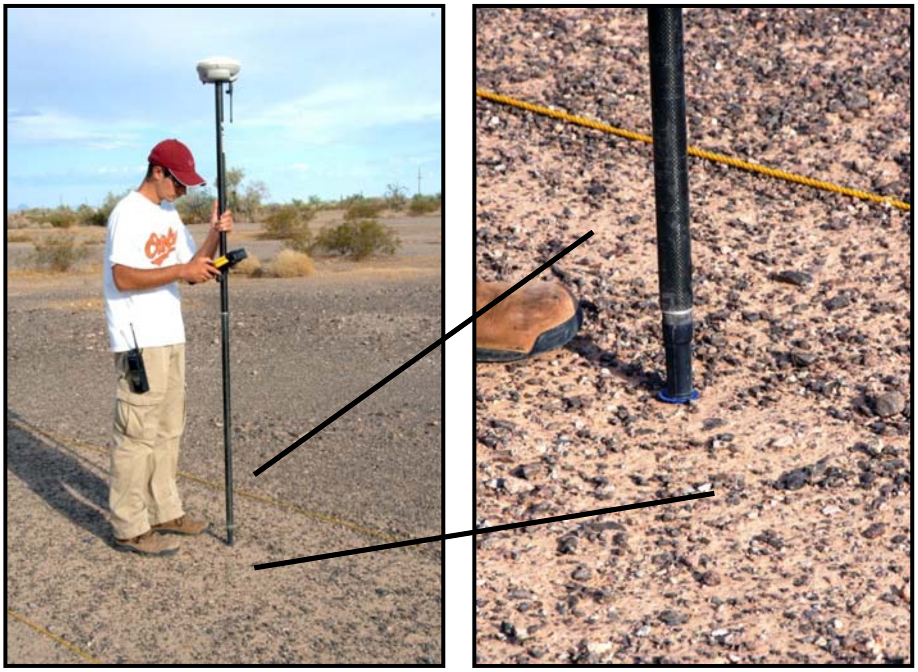

Figure 2. Survey of alarm marker (poker chip).

(3) Reconditioning Test Lanes for Continuous System Performance Missions. After all alarm markers (e.g., chips) and survey points have been accounted for, the alarm marker poker chips can be removed to prepare the lanes for follow on mission runs. The surveyed coordinates are forwarded to the detection scoring team for performance analysis. Test personnel will perform the following steps in preparation for subsequent detection runs to maximize the validity of system performance:

(a) Pick up and arrange the numbered alarm markers in sequential order.

(b) Back drag the lane (see Figure 3) removing any tracks, marks, footprints, etc., on the side of the lane to ensure there are no visual cues left behind from previous scanning process.

e. Performance Data Scoring Methodology. System detection-performance findings must be controlled. Ground truth (target positions) must be treated as sensitive information and not provided to system representatives, test participants, operators, or anyone else unless there is a valid need to know (e.g., calibration or data collection specified test lanes, scoring analyst, etc.). A valid need to know is determined by the test director, project manager, or independent evaluator. Targets will be emplaced by the test team or other special team independent of the

test participants. The initial layout of each test lane/area and subsequent changes to each area will be controlled by the test director and documented by the test observers (e.g., surveyors).

Figure 3. Personnel dragging completed lane to prepare for next run.

f. The primary measures of performance are probability of detection (percent detection), faults alarm rate, and advance rate.

(1) Scoring Definitions:

(a) Percent Detection (PD). The PD provides the finding of target(s) in the detection lane. PD is determined by dividing the number of targets successfully detected by the actual number of targets encountered. A target is considered detected when the alarm marker (put in place by the operator after detector indicates a detection alarm) is emplaced on a target or within a target's halo. A halo is defined as the area within any external dimension of the target; the halo area would be determined by the scoring analyst or evaluator. It is possible for there to be more than one accurate detection of a single target (redundant detection). For the purposes of calculating Percent Detection, only one detection per encounter can be counted. (**NOTE**: even though redundant detections are not considered for scoring, they are also not classified as false alarms)

(b) False Alarm Rate (FAR). The FA is defined as alarm marker of a suspected target that falls outside the halo. The FAR typically calculates false indications by the detector sensor over an area (linear meter by, usually, 1.5 meters wide lane (wide of operator's detector swath)). The FAR is computed as the number of false alarms divided by the area of opportunity for false alarm (scanned area). The area of opportunity for false alarm is computed as the area of the lane (or sensor path/detector swath) minus the area of the targets (and clutter), which includes the area within the halo radius.

(c) Advance Rate (AR). The AR is the time to complete a section of lane/area that you are scanning.

(2) The detection alarm coordinates will be provided to the scoring analyst for processing to determine detection performance. In summary, the general scoring process concept is as follows by the scoring team/analyst:

(a) Generate plots of alarm marker (e.g., poker chip) locations.

(b) Merge alarm plots to target ground truth plots.

(c) Score the alarm files to determine detection performance and false alarms. This is done by determining the standoff distance the alarm mark coordinate point is from the target edge (e.g., target coordinates). If an alarm point is on top of the target or within the halo buffer, it is scored as a "detection". Any distances outside the halo buffer is designated a "non-detection" or FA.

NOTE: Commercial software applications are typically used to assist the scoring analyst/team in merging the digitized alarm coordinates with the digitized target ground truth coordinates to provide an offset distance which then can be sorted by data analysis to which point(s) are inside and outside pre-set distance parameters – the "halo". The halo distance from the target edge can vary (e.g., 4-inches, 6-inches, 10-inches, etc.) depending on the scoring team, evaluator, or system specification scoring criteria.

(3) Scoring. For a target detection to be valid, the detection alarm location must fall within the "halo" - the pre-determined buffer around the edges of a target. The halo edge will follow the contour of the target edges as shown in the halo examples in Figure 4. All detection alarms outside the halo of a target are classified as FAs. Detection alarms associated with clutter targets in the lanes are scored as FAs. For a valid detection, the target must be within a given halo.

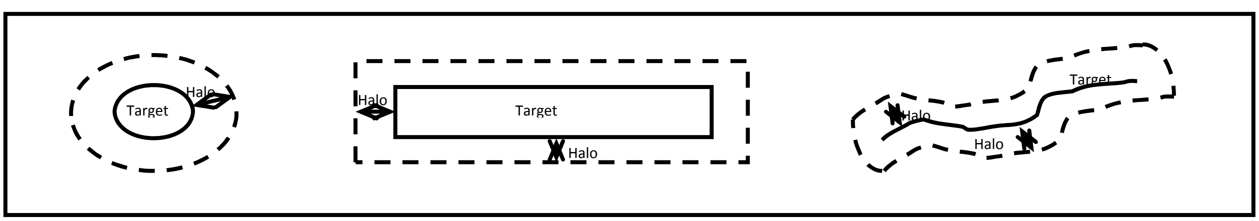

Figure 4. Examples of halo boundary configurations.

(a) Detection alarm markers may be placed in several locations: on top of target or within the halo, outside the halo or away from a target, or on another location around a target (redundant detection) as shown in Figure 5. Redundant detection alarms are not considered and cannot be used in scoring. Typically, in the event of redundant alarms, the closest alarm is declared the valid detection position. Figure 6 is a lane section with examples of detection alarm possibilities. Additional scoring analysis procedures provided in Appendix G.

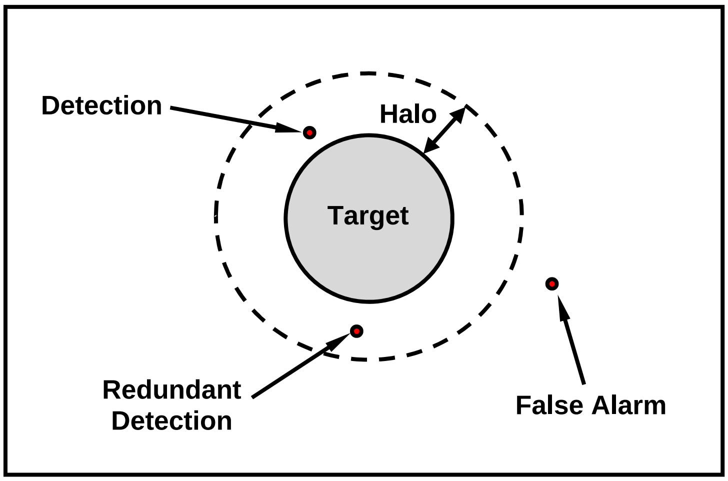

Figure 5. Example of detection alarm variations.

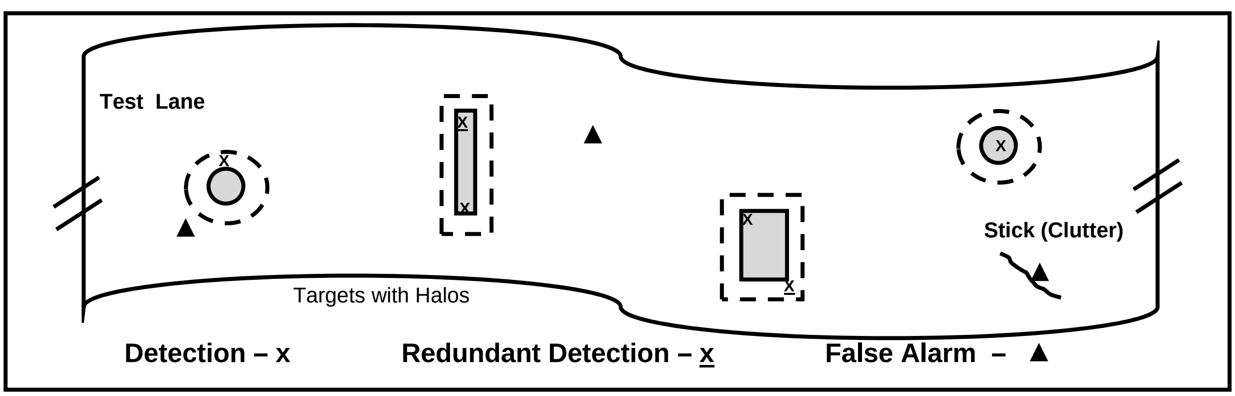

Figure 6. Lane scoring of target example.

NOTE: For a new detection system with unknown performance characteristics, the halo size used for scoring may be adjusted (e.g., increased or decreased) in post test analysis to assess detection performance unidentified characteristics.

(b) Primary scoring formulas for P_D and FAR are shown below:

$$P_D = \frac{\text{Number of Detections}}{\text{Number of Target Encounters}}$$

$$FAR = \frac{\text{Number of False Alarms}}{\text{Lane Area – Target Area}}$$

(c) The data analyst scores the detection effectiveness from the following parameters:

- Calculates the Pd for each target type.
- Calculates the percent detected for target buried depth.
- Calculates the percent detected for each sensor mode (metal, GPR, dual, etc.).
- Calculates the percent detected for entire lane.
- Calculates the percent detected for each operator.
- Calculates the percent detected for all targets as a whole.
- Calculates False Alarm Rate.
- Calculates Advance Rate.

NOTE: Additional detector performance analysis can be performed by the scoring of Pd and FAR using Receiver Operating Characteristic (ROC) curves. ROC curves are used to assess the performance of the ground penetrating radar detector. ROC curves are plots of the P_d vs. the probability of false alarm (P_{fa}) for a given signal-to-noise ratio (SNR). Appendix G provides additional narrative description for scoring and ROC curves.

g. Human Factors Assessment Surveys. The test schedule should allocate time for periodic operator (human factors) interviews, questionnaires, and/or surveys (e.g., post training, mid-test, and post-testing). Care should be taken to ensure that the test participant duty day is representative of the mission profile, to include mission gear if required (e.g., helmet, ammunition vests, belts, etc.). An example operator survey is included in Appendix E.

4.4 System Safety and Human Health.

a. Safety observations shall be made throughout all testing; therefore, a hazard review shall be conducted prior to any testing to make the tester aware of safety measures. Safety-specific and safety-related tests should be planned in addition to regular operations, to thoroughly screen the SUT. The safety testing should be carried out early in the test cycle to establish and confirm inherent safety features.

b. All hazards identified should be evaluated and resolved according to hazard severity and probability. Mitigation of hazards may be implemented of test facility to protect from the fixed design, procedural tasks, or focused training.

c. Hazards should be identified and characterized as to severity categories and probability levels such as those in accordance with risk assessment levels (U.S. Army Test and Evaluation (ATEC) Regulation (Reg) 385-1[5]).

d. The test team will do the following prior to and during testing:

(1) Prior to testing:

(a) Review the TM/OM, prior to testing, and verify that actions, identified to remove or mitigate recognized hazards, have been performed.

(b) Review the materiel developer or contractor's Safety and Human Health Assessment Reports. Coordinate with the materiel developer to ensure a RF radiation, laser, or ionizing radiation study, as appropriate, has been requested and performed, or completed by the U.S. Army Institute of Public Health.

(c) Identify safety problems during test and their classification (hazard severity and probability of occurrence) during initial inspections and during testing.

(d) Complete electrical, mechanical, or miscellaneous hazards checklists to support a safety hazard data collection plan.

(e) Document discrepancy findings of equipment or technical publication and training material review (adequacy of warnings, cautions, and notes).

(f) Review MSDS for the battery and/or any other hazardous elements.

(2) During testing:

(a) Record photographic, audiovisual, or other documentation of hazards.

(b) Record results and classification of toxic fumes (battery).

(c) Document Human Factors and Health Hazards issues: whole body fatigue (weight and balance), noise measures (alarms and headsets), and non-ionizing or ionizing radiation levels.

(d) Assess the adequacy, proper functioning, and need for additional or improved safety and warning devices; i.e., guards, interlocks, alarms, warning lights.

(e) Provide engineering analysis of potential for and documentation of any safety issues/incidents.

(f) Number and criticality of system-related or human/machine interface incidents.

(g) Document operator comments and recommendations regarding:

1 Adequacy and proper functioning of safety and warning devices such as guards, interlocks, or alarms.

2 Weight and balance of detector.

3 Adequacy of safety instructions, guidance in user manuals.

4 Volume and intensity of audio alert tones.

(3) Post testing:

(a) Complete safety report identifying safety discrepancies, test incidents, and information with respect to safety issues or conditions.

(b) Provide materiel developer and/or contractor findings from the TM/OM review and testing of any safety and operational discrepancies or lack of information.

4.5 Climatic Suitability.

a. For all system performance trials, meteorological conditions must be documented and recorded so that the conditions can be characterized in terms of system assessment in reference to climatic conditions. Performance, reliability, discrepancies, or failures can be quantified as a function of a climatic factor. Other types of climatic suitability problems may be solved through changes to design, hardware, procedure, or training. Climatic factors should encompass temperature, solar radiation, precipitation, wind, salt fog, sand and dust, pressure-altitude, and immersion, if applicable to user mission requirements.

b. Testing in climatic chambers and facilities may be creatively exploited, desirably before system performance trials, if facilities can permit operation of detection equipment. Where desired, screening of climatic factors should be combined with the shock and vibration associated with transportation and handling to address storage and transport of packaged equipment prior to handling and operating. Appendix B contains those test standards that may be used if comprehensive screening tests are required. Induced climatic testing may not be necessary if multiple test sites are selected that provide a range of climatic conditions in which performance trials that could include the complete life cycle assessment (e.g., storage, operational use, maintenance, etc) in accordance with the requirements document and associated operational mode summary/mission profile. See MIL-STD-810G for additional detailed guidance on climatic suitability testing.

4.5.1 Natural Environment Performance Testing.

a. The performance of the detection systems will depend very much on the environment to which the system is being operated in. Soil condition, natural and artificial (composition and moisture content), diurnal and seasonal differences, climate, vegetation, and terrain are a few considerations.

b. The use of natural environments at test ranges and climatic selected test areas are more desirable than using test chambers. Based upon definition of natural extreme climatic conditions, conditions expected to be encountered in storage, transit, transport, and operational should be screened using single or multiple factor test. Climatic factors (see paragraph 4.5.2) should encompass temperature, solar radiation, sand and dust, rain, salt fog, etc. Scheduling tests in natural environments should be planned during winter, summer, dry, and wet extreme conditions for the area selected to test items. In accordance with MIL STD-810G, the general guidance on appropriate suitability for testing, appropriate for the intended application, and the level of item assembly required for test should be tailored to simulate operational mission modes. In general, the SUT should be tested at the system level. Test facility induced instrumented systems or subcomponents should be used to enhance data acquisition quality assurance, inspections, and failure analysis or diagnostics, where it can be shown that results are not compromised (e.g., interoperability) or that results are better quantified. Care should be taken to ensure that integral instrumentation is sufficiently rugged to withstand natural and induced environments subjected during testing. Some example testing considerations that should be addressed and considered to assess climatic operational mission requirements include:

(1) Determine testing procedure method(s) (e.g., storage, operational, manipulation, exaggerated, etc.).

(2) Exposure conditions: exposed or sheltered.

(3) Exposure duration.

(4) Exposure temperature at a constant state or cyclic/diurnal cycling.

(5) Packaging configuration (e.g., shipping or storage containers, bare, single item or palletized configurations, etc.).

(6) Representative climate category.

(7) Spectral distribution: sea level versus high ground elevations.

(8) Airflow, if applicable.

(9) Operational checkout points (e.g., pre-checks, periodic throughout testing, post-check, etc.).

c. Ambient Air, Outdoor Tests. Conduct tests of this type under the extreme natural conditions available. Tests will be conducted under full sun and preferably when the air temperature is at an extreme, consistent level. Additional subtest assessments may include:

(1) Human factors.

(2) Exercising all components and ancillary equipment.

(3) Checkout of all electrically operated equipment and lights.

(4) Power consumption.

(a) Low-Temperature Tests (Operational and/or Storage). The low-temperature requirements should be found in the requirement documents or the equipment specifications. The requirements for low-temperature performance are not consistent for all systems (typically because of use mission requirements); the temperature at which certain systems may be introduced often varies. The guidance document must be examined to determine the exact cold-weather performance requirements for the system under test. For storage type tests, thermocouples may be installed at all points where temperature monitoring can be performed.

(b) High-Temperature Tests (Operational and/or Storage). The high-temperature requirements should be found in the requirement documents or the equipment specification. For storage type tests, thermocouples may be installed at all points where temperature monitoring can be performed. Ambient high temperature testing should be above 32 °Celsius (C) (90 °Fahrenheit (F)).

d. Other Conditions (to assess operational and human factors elements) include:

(1) Assess the SUT to operate in various environmental climates (e.g., hot desert, tropical, cold (frozen) tundra, and surf (beach).

(2) Assess in direct sunlight, and overcast cloud cover.

(3) Assess in windy, blowing conditions (e.g., dusty, blowing snow, etc.).

4.5.2 Induced or Chamber Environmental Conditioning Testing.

Where natural climatic temperature testing cannot be performed, simulated temperature conditioning may be required to assess the SUT in both the storage and operational configurations.

a. Testing in climatic chambers and facilities could be creatively explored; however, the size and scope of testing desired (e.g., detection assessment over targets) could severely restrict the use of environmental chambers other than basic operational performance parameters, (e.g., on/off, power limitations, operator/machine interface, electronic parameters, etc.).

b. The effect of an environment on the aspect of system safety should also be tested.

c. The minimum sample size for any exposure should be determined by the configuration of the system being tested. Any existing data from the developer/contractor’s may be reviewed. The developer's/contractor’s tests can be monitored and/or witnessed, and a determination made as to whether to accept the data or recommend additional screening tests.

4.5.3 High Humidity.

The SUT may need to be tested in high humidity environments to determine the affects of corrosion, electrical malfunctions, swelling of nonmetallic materials, loss of insulating qualities, deterioration of hygroscopic materials, etc. If systems have an LED screen, fogging or moisture accumulation may be observed.

4.5.4 Fungus Resistance.

Fungus resistance can be ascertained by an examination of the materials composition of the SUT, and from certification by the developer that the materials used in the test item are fungus-inert or impregnated with fungus-resistant material. If considered necessary, specific fungus tests should be planned. Allow a minimum of twenty eight days for fungus germination and exposure analysis.

4.5.5 Salt Spray (Fog).

A salt spray (or salt fog) test may be necessary if the SUT is likely to be operated or deployed in a marine environment, to include surf beach regions.

4.5.6 Sand and Dust.

This test is conducted when it is possible that sand or dust could interfere with moving parts, fans, hand controls, etc. One or multiple testing procedures should be selected; testing procedures consist of Procedure 1 - Blowing Dust; Procedure 2 - Blowing Sand; and Procedure 3 - Settling Dust.

4.5.7 Solar Radiation.

This test is primarily conducted for heat effects. In view of the previous high temperature tests, the solar radiation test may be unnecessary. One or multiple testing procedures should be selected; testing procedures consist of Procedure 1 - Cycling Heating Effects; and Procedure 2 - Steady State Actinic Effects.

4.5.8 Immersion.

Depending upon the requirements, an immersion (water-tightness) test should be carried out in addition to the rain test to check seals and protection of electrical connections.

4.5.9 Rain and Freezing Rain.

An immersion test may make a rain test unnecessary. Freezing rain tests should also be considered in conjunction with the low temperature tests. One or multiple testing procedures should be selected. Testing procedures consist of for the following:

a. Rain.

(1) Procedure 1 - Rain and Blowing Rain.

(2) Procedure 2 - Exaggerated.

(3) Procedure 3 - Drip.

b. Freezing Rain.

4.6 Transportation and Handling.

a. Transportation and handling tests will reflect the logistics and mission environment. Specific screening tests will be conducted as a necessary measure to support transportability certifications and safety assessments. Screening tests will focus on intermodal transport, air delivery (containerized), and handling related shock and vibration effects on the item and will be coupled with climatic conditions. Detailed technical inspections will be incorporated into all tests involving shock or vibration whether they are conducted singly or in sequence as a test control. Packaging configuration should be tailored to the planned life cycle (palletized, crated, bare). Testing should be planned to explore whether the item is safe to handle and operate following transportation and handling subtests; these samples could possibly also be used as part of the reliability, or performance subtests, as well as, safety data to support safety assessment of SUT hardware. If necessary, special tactical mockups may be fabricated to physically simulate the carrier (vehicle bed, helicopter storage compartment, storage rack, etc.).

b. A typical logistical depot/mission/field movement profile should be constructed to identify transportation and handling subtest specifications (e.g., port or air transport staging area - transport to forward supply point (by truck or helicopter) - then transported and handled at mission/field use point (by personnel carriers, Mine-Resistant Ambush Protected (MRAP) vehicles, dismounted, etc.)). Tactical vibration profiles should be developed or identified, and used for all items to simulate being transported in through the logistics life cycle. These vibration tests could be in conjunction with other logistics-related sequential testing (e.g., secured cargo (container/palletized), loose cargo (container, bare, or both), and 7-ft drop (packaged in container or other carrying apparatus), and 4-ft drop (bare) subtests).

c. Appendix B, TableB-1 contains those test standards that may be used if screening tests are required. Screening tests will focus on ground, water, and/or air transport (containerized), air delivery, and handling related shock and vibration effects on the item and should be coupled with climatic conditions as stated above. Other testing sources are outlined in the following:

STANAG 4138 (Vibration Resistant Equipment)[6], and MIL-STD-810G (Method 514 - Vibration).

NOTE: Special considerations are testing with or without power supply (e.g., battery(s), etc.), and at what intervals to perform an operational check using standardized target sample(s) for each sensor component.

4.7 Integrated Logistics Supportability.

a. Logistics Supportability does not necessarily lend itself to standardized test design in a technical testing forum. Therefore, overview assessments for logistic supportability can be integrated with Logistic Support (LS) requirements (packaging), RAM, and the Human Factors data elements of the SUT. Data are collected during all phases of testing. Suggested focus categories for assessment that should be relative to requirements, observations and consideration are outlined as follows:

(1) Transportability.

(2) Equipment publications.

(3) Training.

(4) Test, measurement, and diagnostic equipment.

(5) Tools.

(6) Spares and repair parts, etc..

b. The test team should perform the following:

(1) Assess the shipping container or packaging configuration for the following:

(a) Protection of equipment and accessories.

(b) Adequacy of securing all components.

(c) Ease of use and handling (e.g., opening and closing, extracting and stowing of components, etc).

(d) Ability to stack; maximum quantities allowable for stacking.

(e) Size and weight.

c. Assess the TM/OM for completeness, comprehension, troubleshooting procedures and cautions/warnings. Discrepancies should be identified to assist in the updating of the TM/OM for future updates.

NOTE: For any TM/OM safety discrepancies, mitigating measures should be implemented to protect operator(s) and/or test personnel during test and evaluation assessment trials.

d. Review any proposed training plans needed for test personnel to perform the test and evaluation assessment of the SUT. Some training requirements for testers may be modified, shortened, and enhanced than what is developed for military user operators. However, this training may provide the Program Manager (PM), military trainer, and/or contractor developer opportunities to determine what are the important and effective points/practices to incorporate into the overall military user formal training program.

e. Inventory any tools and/or special pieces included with the SUT that are required for use and/or for operator level maintenance. Identify any tools required not provided or listed in TM/OM that were necessary to operate, maintain, or repair SUT. If any unique or measuring/diagnostic equipment is necessary to operation, maintain, or repair the SUT not listed in TM/OM, indicate as a discrepancy.

f. Inventory all spare parts included with each SUT. Document any spare parts supplied during testing. Determine if these spare parts are commercial off the shelf items or specialized parts/components. Having backup SUT or any specialized parts/components on hand during testing, may prevent or reduce significant down time during testing if a failure is experienced.

g. Other elements for assessment considerations:

(1) Adequacy and/or availability of special tools, test, measurement, or diagnostic equipment.

(2) Availability of batteries (e.g., supply, commercial, commonality, etc.).

4.8 Reliability, Availability, and Maintainability (RAM).

While testing, collect operational and maintenance data to determine overall ability of the system to complete task/mission. Record RAM data elements to determine mean time between maintenance ratios, operational time between battery replacement, etc. Track scheduled and unscheduled maintenance tasks, as well as, preventative maintenance procedures. Testing should be planned to examine reliability and durability of all SUT essential features with special emphasis on the reliability of safety features.

NOTE: Record any compatibility problems noted during operations (human factors) or maintenance.

4.8.1 Reliability.

The reliability testing of the SUT requires the conduct of a significant number of repeated activities and operational run time. The activities will be based on a typical operational mission of the SUT and should be defined in the user requirement documents. The number of repeats (e.g., target encounters, operational time, etc.) required will be established to ensure statistical validity of the results.

a. Perform daily operator PMCS as specified in the TM/OM.

b. During system testing, collect data on the battery usage, record average battery life, and adequacy of low battery indicators prior to system degradation/shutdown. Include data on ease of battery replacement. Also note the availability of the required battery (rechargeable or not) and whether they are commercial-off-the-shelf or military type batteries. Key battery data elements to monitor:

(1) Battery operational time.

(2) Battery charge time.

(3) Adequacy of battery charger.

c. In the event of a system, subsystem, or component failure, malfunction, or performance inadequacy, collect data on faults, discrepancies, and issues, and record in test log books.

(1) Description of failure, malfunction, or performance inadequacy causing a system performance discrepancy.

(2) Description and function of the specific subsystem or component that failed or having questionable operational issues.

(3) Description of subsystem or component discrepancy, if possible, and impact on system performance.

(4) Description of corrective action/troubleshooting procedures, including time and level of maintenance required to correct discrepancy.

(5) System performance after corrective action.

(6) Repairs and/or maintenance beyond the scope outlined the TM/OM performed by the Field Service Representative or test personnel (with or without developer’s guides).

4.8.2 Maintainability.

a. All maintenance operations required during the course of testing should be performed in accordance with the applicable TM/OM, or recorded if the system's Field Service Representative performs the maintenance task. Preventive maintenance should be performed at the specified intervals. All crew, organizational, direct and general support maintenance actions should be monitored to accumulate required data. Operator's daily checks and services should be observed sufficiently to obtain representative times for performing these tasks. A database should be used in the collection and analysis of this logistic supportability data (e.g., test incident reports (TIRs) should be posted in the Army Test Incident Reporting System (ATIRS)).

b. No simulated maintenance should be performed. All maintenance operations required to maintain the system in an operational status should be monitored. Factors which establish that ease of maintenance should be examined relative to the design of the system. Assess and document the reliability of components and other factors which indicate that the equipment design either has or has not been directed toward minimizing maintenance. TM/OM should be used as a guide in determining maintainability-design characteristics. If none are provided, request instructional guides from the field service representative or system developers, and record executed maintenance procedures utilized for a given maintenance task. These procedures can then be provided to system developer as a template to start a guide or manual. Maintenance checklists, observational data records, and failure reports are used to acquire the maintainability data.

c. Throughout all maintenance operations, observations involving the man-item relationship and safety of maintenance should be recorded.

d. During all preventive and corrective maintenance tasks performed, the appropriate manuals provided for support of the test items should be reviewed, and comments on their accuracy, adequacy, and safety instructions for personnel and equipment, to include environmental protection during operation and maintenance (e.g., battery disposal), should be identified and recorded.

e. Repair parts should be examined with respect to the maintenance category authorized to stock and/or requisition the part, and the category prescribed to replace the part. Parts should be examined to ensure modular design has been considered and they should be compared with the repair parts outlined in the TM/OM; this assesses the TM/OM to ensure it is adequate.

f. During all maintenance operations, the tools and test equipment authorized in the maintenance support literature should be used in accordance with instructions contained in applicable equipment publications. If such a list of authorized tools and test equipment is not provided, verify with system developer that suggested tools/test equipment will work for required maintenance, and seek their authorized for use in the maintenance of the SUT.

4.9 Human Factors or Ergonomics.

Human factors assessment needs to be integrated into all phases of testing. Quantitative and qualitative data are gathered, as applicable, for both the packaged and bare items relative to functions such as assembly/disassembly, operability, transportability, portability, and usability. Specific human factors test procedures, checklists, and questionnaires will be used (see Appendix E for examples) to examine design, tasks, operator performance, and adverse natural or induced environmental conditions.

a. Standardized and/or customized questionnaires are administered to test team participants (operators) during and after system performance trials to aid in appraisal of training, hardware, and equipment publications. Questions and request for comments should direct operator responses to provide more than a "Yes/No" reply. Encourage descriptive responses to provide liberal feedback, both constructive and negative, even suggesting their recommendations or ideas.

b. Adverse environmental conditions should be included to examine the effects of extreme climates and other induced conditions such as nuclear, biological, chemical (NBC) relative to compatibility with combat clothing and equipment on the ability to perform key functions (e.g., system assembly, scanning operations, change out of batteries, monitoring alarms, etc.). Test design should include simulation of mission or work cycles. Personnel should include trained engineering technicians, as well as, personnel who are representative of the intended military user population in terms of skills, size, strength, and wearing suitable garments and equipment appropriate to the tasks. Data will be gathered to identify and define the test participants (user population). Sufficient data will be acquired to establish the demographics, anthropometry, skills, grades, experience, gender, handedness, and sensory acuity (visual and auditory). Subjective data, including that from interviews and questionnaires, should be taken during testing and should be repeated to show learning effects as well as to examine the ease of use. Interviews should be structured and surveys scaled to provide quantitative comparison of responses.

NOTE: Minimize the collection personal identification information (PII) and prevent storage of PII. Code the operators (e.g., Operator A, Operator B, etc.), and correlate the demographics, anthropometry, and other information to the operator's code ID.

NOTE: If key user representatives are not available, a complete training program needs to be provided to the selected operators so they can become confident to operate the SUT and to at least provide applicable/knowledgeable comments on the SUT in questionnaires and/or operational surveys.

c. Additional human factors engineering data may be gathered to examine operator health environments to ascertain the severity of hazards associated with use. These may include non-ionizing radiation hazards due to lasers or radio frequency communication, impulse noise and overpressure, weight, and sharp edges. Findings that indicate hazard severities that require mitigation will be collated to the safety subtest. The best way to measure the audible warning

sound piped into a headset is by using specialized manikins, following American National Standards Institute (ANSI) S12.42[7] procedures.

d. An analysis of the SUT may be required to identify the requirements for operator and maintenance training. Other agencies may have input for training and maintenance requirements, and these procedures/processes may be integrated during testing to review the practicability of any identified implemented procedure/process.

4.9.1 Human Factors Testing Elements for Considerations.

a. Record demographics and anthropometry elements of test participants, to include corresponding apparel (Mission Oriented Protective Posture (MOPP), arctic, battle dress uniform) and accessories (pack frame, weapon, etc.) on test participant. Data should include MOS or civilian equivalent, time in specialty, and years and months of related equipment use.

b. Provide operator and maintainer questionnaires to complete.

c. Record observation assessments of operator(s) during operational use.

d. Assess hardware design:

(1) Lighting measurements of displays - night and day.

(2) Noise levels related to operational awareness and detection alarms.

(3) Labeling and color coding/marking of safety warnings and placement locations.

(4) Weight of test item in packaged and unpackaged state, handholds, latches, etc.

(5) Ease and comfort while holding detector for detection scanning.

(6) Balance of system to assist with operator performance of scanning duties.

e. Assess the portability and human interface features (e.g., easy of comfort, hand-grip ergonomics, operational stress points on operator associated with straps, balance, rubbing against body, heat elements, etc.).

f. Determine the capability of mine alarm signals to inform operator:

(1) Description of the types and characteristics of signals.

(2) Description of any intensity adjustability of signals.

(3) Adequacy of the ease of discriminating visual display signals from other operational indicators.

(4) Adequacy of the audio signal intensity in typical operational environments.

(5) Operator comments on the ease of interpreting the meaning of visual and audio signals.

g. Assess the attachability (if applicable) of SUT hardware to operator tactical belts, vests, or other accessories (e.g., battery packs, carry straps, spare parts, etc.):

(1) Ratings of ease of attaching system components to, and removing components from, human accessory.

(2) Documented observations of any difficulties with lifting, positioning, and securing components on operator.

(3) When SUT is attached to operator, description of any operator limited or restricted movement.

h. Document the ability of the operator to perform PMCS in the required time using instructions provided with the system hardware.

(1) Ease of performing PMCS.

(2) Time to perform PMCS during the day and night.

(3) Adequacy of instructions.

(4) Ability of operators to operate the system while attired in environmentally protective clothing.

(5) Listing of all protective clothing ensemble components worn (e.g., civilian street attire, military battle duty uniform, coverall/overalls, cold weather gear, biological attire, etc.). Also identify if hearing audio ear piece restricts operator to wear head gear or helmet.

(6) Compatibility of SUT hardware with protective clothing, with an emphasis on hand gear (e.g., gloves).

(7) Documented observations of task completion difficulties (e.g., assembly/disassembly, operating, PMCS, battery replacement, etc.) experienced by operators.

(8) Ease or difficulty of adjusting controls barehanded, wearing protective gloves, and while wearing NBC and cold weather protective gloves.

i. Document the ease or difficulty of the ability of the operators to set up, operate, and maintain the system:

(1) Adequacy of system to alert the operator to buried threats (e.g., mines, IEDs, pressure plates, IED wire, etc.).

(2) Adequacy of hardware to verify locations of buried threats (e.g., mines, IEDs, pressure plates, IED wire, etc.).

(3) User confidence regarding the ability of system to accurately find and pinpoint buried threats (e.g., mines, IEDs, pressure plates, IED wire, etc.).

(4) Description of operator errors, as well as, their consequences on overall system performance (e.g., in correct calibration, power level awareness, continuous scanning height above ground, etc.).

(5) Adequacy of progressing through SUT menu during PMCS, pre-operation calibration, during detection scanning operations, warning resets, error resets, etc.

j. Illustrative photographs when measurements or user comments show a problem that reflects a human machine interface issue.

k. Observe operators if mission fatigue causes operational issues, but not limited to:

(1) Scanning technique becoming erratic (e.g., not scanning the ground evenly across the surface at the specified height and speed, etc.).

(2) Fatigue causing the operator to shorten the scanning duration, requiring more frequent breaks.

4.10 Electromagnetic Environmental Effects (E3) and Vulnerability.

a. Testing should be designed to reveal vulnerabilities of design or hardness of the SUT design. Vulnerabilities could be false or improper detections or reversible/irreversible degradation following exposure to the phenomenon (e.g., simulated E3 testing effects). Where possible, testing that reveals vulnerabilities should also examine whether hardening, proliferation, or dispersion would solve the specific vulnerability.

b. Perform testing to the degree necessary to determine the effects of E3 upon the operational capability of the SUT with respect to its operational role in the military forces, equipment, and systems. E3 testing should encompass all electromagnetic disciplines, including electromagnetic compatibility/electromagnetic interference, electromagnetic radiated emissions, electromagnetic vulnerability, electronic pulse, electronic counter-countermeasures, hazards of electromagnetic radiation (EMR) to personnel, ordnance and volatile materials, and natural phenomena effects of lightning and electrostatic discharge. Levels of E3 phenomenology shall be based on projections of threat and friendly offensive radio frequency (RF) capabilities, tactical and fixed radars, tactical and fixed communications and electronics, commercial emitters, broadcast stations, amateur radio services, and threat and friendly jammers. E3 testing is

considered part of vulnerability testing, but is given special consideration due to the prevalence of E3 in the logistics environment and on the modern battlefield.

c. If E3 testing is deemed necessary, specialized test equipment may be used to provide controlled emissions for testing. The following procedures can be used as a conceptual guide.

(1) Place the SUT antenna above ground about the height used to scan the ground in an operational mode. Have a calibration target place to perform pre-emitting scans and to scan during test emissions.

(2) In accordance with testing standards the RF environment should be adjusted to generate a continuous wave (CW) and pulse modulation field at the desired frequency. The operational environment should be adjusted to generate amplitude and frequency modulation fields.

(3) Transmitter power should be slowly increased until either the criterion field or facility limitation or personal exposure limits (PEL) are reached.

d. The above procedure should be repeated for all selected frequencies, modulations, polarizations, and orientations.

e. For observed anomaly, the threshold field intensity at which the malfunctions appeared should be determined by additional test runs in which the E3 test environment is increased until the field intensity is reached at which the anomaly occurred. This additional test run will also suffice as a check to ensure that the electro-interference was the cause of the anomaly.

f. For compatibility testing of RF emissions (e.g., jammers, tactical radios, etc.), determine what the operational distance can be performed without degradation to the detection system normal operating modes. With friendly emitters off, scan over a valid target; with emitters on, scan over target to determine if any degradation is experienced. Repeat by expanding the separation distance between the detector and emitter until no degradation observed.

NOTE: Testing results typically are classified and data security handling measures must be considered.

4.11 Software.

a. Software testing techniques will vary dramatically and may not lend themselves to standardization. Software should be baselined prior to test start and should be maintained throughout each test session. See ITOP 04-2-520[8] for guidance on software testing. Testing software is necessary to ensure that safety is designed into the software algorithm, and that safety is maintained throughout the software life cycle. It provides uniform procedures for developing and implementing a safety critical software test methodology to identify the software caused hazards/faults. The objective is to ensure that the software design takes positive measures to

enhance system safety, and that software errors which could reduce system safety have been eliminated or controlled to an acceptable level of risk.

b. The test team will capture following data elements:

(1) Software version at start of system performance trials.

(2) Problems attributable to software related to system diagnostics or system performance.

(3) Identify and record software revisions during testing and when it was changed.

(4) Outlining when a new version of the software is installed and why, and what did the revision correct/enhance/provide.

5. DATA REQUIRED.

a. The data requirements are identified in the planning phase from system specifications and critical operational requirements. The requirements are documented in the test plan and concurred by stakeholders before the test starts. Data requirements should be identified for each subtest to reflect information necessary for diagnostics and for the analysis of the SUT essential features. SI-units should be used.

b. The following data elements are broken down into the various subtest data requirements. The test team will record the following:

5.1 Receiving/Initial Inspections.

a. Inspections prior to and during testing.

b. Operational readiness, safety checks and inspections, and results of initial functional check(s).

c. Description of packaging, item nomenclature (serial number or identifying number), item type (if special variants are built), and quantity of each type of test item(s):

(1) Major component serial numbers and proper title (name of component)/nomenclature.

(2) Subcomponent serial numbers and proper title (name of component) /nomenclature.

(3) Cross reference to any local numbers/codes applied for testing.

d. Descriptions and photographs of shipping configuration packaging and detection system damage or discrepancies.

e. Document completeness of the SSP received for the test (manuals, repair parts, tools, etc):

(1) Calibration tools/devices.

(2) Batteries.

(3) Battery Chargers.

(4) Cables.

(5) Calibration pieces.

f. Record component(s) operational status, which items needed maintenance, and software upgrades. Record final software version and all upgrades implemented during testing.

g. Record of hardware/software adjustments/modifications made prior to and during testing.

h. Record any safety or human factors problems.

i. Document compliance/noncompliance with test criteria or hardware specifications.

j. Identify radar operational frequencies (**NOTE**: radar frequencies are provided to range frequency spectrum managers to acquire frequency allocations to permit authorization to emit for/during testing).

5.2 Physical Characteristics.

Record physical characteristics prior to the start of testing with a representative sample of SUT configuration provided/received for testing:

a. Weights of all major components and shipping containers (± 0.001 kilogram (kg)).

b. Dimensions of all major components and shipping containers (± 0.1 cm).

c. Physical characteristics of the SUT in the stowed and deployed configurations.

d. Center of gravity of SUT in various adjustable configurations, as required.

5.3 Performance.

5.3.1 Common Data Requirements for All Trials (Mission Runs).

5.3.1.1 Administrative Data.

a. Trial ID number.

b. Trial date.

c. Test player ID number.

d. Test player equipment and clothing (as appropriate, for collation to human factors appraisal).

e. System ID number.

f. Test player team ID number, if teams of individuals are used for search method.

5.3.1.2 Ground Truth Data.

a. Target description data.

(1) Record of each unique target ID number.

(2) Tabulated composition of each target type.

b. Collect, measure, and record the items as following:

(1) Configuration of every threat and clutter target.

(2) Surveyed coordinate position of every target (ground truth).

(a) Exact coordinate location of every target.

(b) Depth.

(c) Plotted ground truth (spreadsheet and graphical image).

c. Identify target code categories to maintain data unclassified (see Appendix C for target categories).

5.3.1.3 Mission Data for Each Trial (Mission ID).

For each detection mission, log the test lane identification number and the administrative data listed in paragraph 5.3.1.1, as well as the following data:

a. Run Start Time; Detector ON time.

b. Run Stop Time; Detector OFF time.

c. Start Point (geodetically marked) (beginning of lane).

d. Geodetic path of lane.

e. Stop Point (geodetically marked)(end of lane).

f. Detection alert number over the entire lane.

g. Time of each alert.

h. Alert status (e.g., targets, clutter, false alarm, etc.).

i. Detection alarm sensor (e.g., metal detector, GPR, etc.) when each sensor is activated, individually (de-coupled) or combined.

j. Alarm type (e.g., audible, LEDs, etc.).

k. Power Supply (battery use information):

(1) Battery type.

(2) Battery ID.

(3) Battery start and stop time.

(4) Provide an overview of the supplied power supply to assess battery power supply availability (e.g., battery logistic supply, battery power charging requirements, NATO adapters, etc.).

(5) Time duration SUT will operate with single set of MIL-SPEC batteries before giving a “Low Battery” warning.

(6) Once the Low Battery warning is activated, determine duration how long detector stays operational before a “Critical Low” warning is given or SUT turns off.

(7) Calculated average battery life when using the SUT.

l. Detection Alert Confident Level (High or Low).

m. Results of performance detection test.

(1) Quantity of alert markers used during each mission.

(2) Number of detections.

(3) Number of false alarms.

(4) Time to complete each test area/test route.

(5) Elapsed time SUT was on.

n. Failures found by any means, including during PMCS, BIT, or missions.

o. Results of all BIT.

p. Meteorological data (regardless of whether natural conditions or artificially developed conditions):

(1) Air temperature.

(2) Precipitation, duration, intensity, accumulation, and phase (rain, snow, etc).

(3) Wind speed/direction.

(4) Barometric pressure.

(5) Relative humidity.

(6) Ground (soil) temperature.

(7) Cloud cover, description/height.

(8) Time of Day.

q. Other target truth data unique to the environment or detector type (temperatures of backgrounds, solar loading on detector components, targets, etc.).

r. Soil data (from each test lane).

(1) Soil characteristics and classification.

(2) Sampling equipment and methods used to characterize soil type.

(3) Metal content.

(4) Soil composition.

(5) Soil texture.

(6) Rock distribution.

(7) Moisture content and method used to characterize moisture or control moisture.

(8) Vegetation type with narrative description, photographs, and physical survey locations within the lane boundaries.

NOTE: Identify any other unique soil properties or soil features that may be of interest for specific sensor types.

5.3.2 Sensor Performance and Recommended Analytical Methods.

Sensor methods are continuously evolving in the attempts to standardize. Certain key definitions of interest for the evaluation of sensor performance are presented in paragraphs 5.3.2.a(1) - (7). Sensor performance analytical methodologies are presented in paragraphs 5.3.2.a, b, and c, to provide a starting point for detection analysis of detection data in a manner relevant to dismounted detection systems/operations.

a. For detection systems, other than mine detection systems, the term target may be used interchangeably with mine and pressure-plate improvised explosive device (PPIED) components (e.g., trigger mechanisms, command wire, and main charges, etc.) without affecting the definitions or analytical methods below.

(1) ROA = Rate of Advance = Area/Unit of Time (Dismounted Systems) (m^2/hr).

(2) ScR = Scan Rate = Area Scanned or Covered/Unit of Time (m^2/hr).

(3) SwR = Sweep Rate = Distance Traveled (lateral sweep)/Unit of Time (m/hr);

AR = Advance Rate = Linear Forward Progress/Unit of Time (m^2/hr).

(4) Detection Probabilities:

$P_{d(true)}$ = Number of Targets Detected/Total Number of Targets (N)[see note 1] *(in Lane)*

$P_{d(measured)}$ = Number of Declarations that meet the rcrit (mine+halo) criteria/(N)[see note 2]

NOTE 1: $P_{d(true)}$ implies that lucky matches may occur.
NOTE 2: $P_{d(measured)}$ implies that due to target merging, two targets may appear as one or that multiple declarations may need to be rescored as one declaration after review of truth and test data.

(5) FAR = False Alarm Rate = False Alarms/Unit Area or False Alarms/Linear Distance along a specified track or front width.

(6) P_{FA} = Probability of False Alarm.

(7) r_{crit}=Critical Radius or "halo"[see note 3].

NOTE 3: Each detector will have a critical radius or "halo" in which a detection can occur at a distance relative to the center of the detector head (see Figure 7). This implies that a detection can occur with a standoff distance between the center of the detector head and the edge of the target(s). The "halo" performance envelope is determined experimentally for each integrated sensor type. It may be circular (implying an equidistance in all directions) or perhaps an irregular footprint area when overlaid on the surface of the ground. Therefore, r_{crit} or "halo" implies the distance or footprint area in which a detection alert can occur with reasonable probability. Hence, a marked detection that occurs within the r_{crit} or "halo" is scored as a valid alert (see Figure 7).

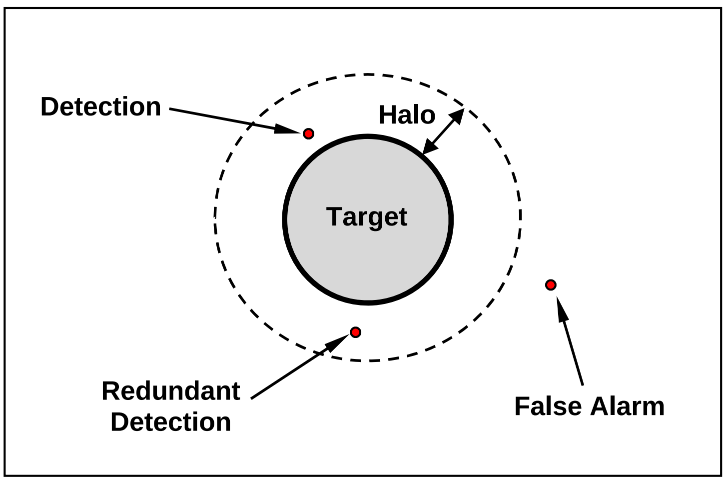

Figure 7. Target halo configuration.

b. Analytical Scoring Concept. For the detection alarms obtained during the scanning of the test lane, a determination must be made regarding the “scoring” of reported detections as valid or invalid (e.g., detection or false alarm). The accuracy criterion will be used to make this determination; for example, if the location of the detection declaration is within a “halo” about the perimeter of the target that is the distance of the accuracy requirement away from the target, the detection is considered valid (see Figure 7). Thus, all valid detections will, by definition, meet the location accuracy requirement. The method for scoring the accuracy of results will or may be DGPS survey coordinate system overlaying the target alarms coordinates to the ground truth coordinates.

c. Definitions. Although, it is possible for there to be more than one accurate detection of a single target (more than one indicator within the accuracy requirement (see Figure 7, Redundant Detection), for calculation of the probability of detection (P_d), only one detection per encounter is counted. This is because P_d is a probability which must be accumulated on a per encounter basis; if the total number of accurate detections (which could be more than one per encounter) and the total number of encounters are merely accumulated, the result might show a

higher P_d than was actually demonstrated (the calculated P_d could conceivably be greater than one). However, a count will be kept of the number of additional accurate detections (Aa) per target encounter and the results will be reported. Although this is or may not be directly related to a user requirement, it is a useful measure, in addition to the FAR, of the degree to which an overly sensitive system might impede the detector and operator's forward movement. It is intended that P_d, FAR, and Aa be analyzed as a function of operator, soils, climate, advance rate, target type(s), etc.

The following defined parameters apply for the detection tests:

E = an encounter of a target by the sensor ($\Sigma E=N$)
R = a reported detection
A = an accurate detection; i.e., a reported detection within the required accuracy (defined by the critical radii (r_{crit})) or "halo" of any mine detection system)
S = a single, "scored" accurate detection for a single encounter
Aa = an additional accurate detection
FA = False alarm: a reported detection outside the allowed accuracy (defined by the critical radii (r_{crit})) or "halo" of any mine detection system)
FAR = the sum of FAs per linear km searched

Thus,

$P_d{}^* = \Sigma S/\Sigma E$ (where $P_d \leq 1$)
$\Sigma Aa = \Sigma(A - S)$
$\Sigma FA = \Sigma R - \Sigma A$
$FAR = \Sigma FA/km$ *or unit area*

NOTE: P_d for any minefield test area with a given set of conditions should be presented in test reports as a numerical ratio, rather than a point estimate. This will allow for statistical tests and combining of data where possible.

5.4 System Safety and Human Health.

a. List of safety hazards from the TM/OM, or supplied safety assessment documents/analysis.

b. Results of SUT safety inspections and operational checkout.

c. Warning or cautions not properly labeled on detector or listed in the SUT TM/OM.

d. List of any safety hazards observed during testing, and what mitigating steps or protections were implemented during trials or proposed.

5.5 Climatic Suitability.

Generic data requirements are as follows (if applicable to a specific subtest):

a. Ambient air temperature.

b. Conditioned chamber temperature.

c. Conditioned water temperature.

d. Time versus temperature charts.

e. Solar radiation (irradiance intensity).

f. Relative humidity.

g. Salinity of solutions (mineral salts used for testing).

h. PH of solutions.

5.6 Transportation and Handling.

a. Testing temperatures.

b. Time versus temperature charts.

c. Pre- and post-photographs of testing configuration and SUT.

d. Document testing configuration (e.g., containerized, bare, deployed or stowed configuration, etc.).

e. Document testing with or without power supply.

f. Vibration spectrums and/or drop heights.

g. Vibration spectrum versus time charts.

h. Identify target sample for operational verification.

i. Document any test or operational checkout discrepancies.

5.7 Integrated Logistics Supportability.

a. Photographs of the shipping and/or packaging configuration(s).

b. Physical weights and dimensions of the shipping/packaging configuration(s).

c. Document any human factors handling issues in the use and handing of the SUT interface with shipping/packaging container(s).

d. Document the TM/OM publication (or draft) date and version number.

e. List the TM/OM discrepancies; identify the TM/OM safety discrepancies and what mitigating measures were implemented for test.

f. Identify any special training procedures that were implemented for assessment of the SUT, and any procedures that were not included that would be vital for military users.

g. List the spare parts, tools, special equipment, etc.

h. Identify the type and quantities of the battery(s) used for test.

i. Identify disposal requirements for batteries.

5.8 Reliability, Availability, and Maintainability (RAM).

a. RAM data elements to document during testing that should be considered:

(1) Record of scheduled and unscheduled maintenance activity.

(2) Time for typical PMCS.

(3) Maintenance task(s) performed.

(4) Clock hours of maintenance task(s) performed.

(5) Record of SUT failures, malfunctions, and/or errant behavior.

(6) Operator's corrective action to fix a detector operational issue, and time for fix (minutes).

(a) Identification and nomenclature of parts involved in maintenance action.

(b) Reason for maintenance action, or action taken to get SUT operational (repair, replace, adjust, calibrate).

(7) Adequacy of manuals (legibility, readability, applicability, completeness) to include handling instructions.

(8) Adequacy of instructional training for scheduled and unscheduled maintenance tasks, if applicable.

(9) Adequacy to access the components for operator level maintenance tasks.

b. Other maintainability data elements for consideration:

(1) Adequacy of supplied or TM/OM identified special tools, test, measurement, or diagnostic equipment.

(2) Document how long the battery lasts before needing replacement during missions (e.g., minutes, and/or hours).

(3) Assess the TM/OM for publication version updates (e.g., does it include latest versions of the SUT modifications, enhancements, software control elements, etc.).

5.9 Human Factors or Ergonomics.

The following data are required for human factors related assessment:

a. Anthropometric and demographic data of the test participants (operators).

b. Document the skill level of the operators (previous use of detectors).

c. Photographs of operators holding equipment in packaging and bare configurations, to include assembly and assembled modes.

d. Record the level and duration of training provided, and document operator’s comments on the training and their confidence level after the training in questionnaires and operator interviews.

e. Record the safety checklists and identify the hazards.

f. Document the operator’s ability to perform key operational functions of assembly, operate, scan, and disassembly of the SUT.

g. Document fatigue level observed while operator performed mission scanning operations.

h. Photograph operator with ear piece, if applicable.

i. Results of visual and auditory assessments of the SUT operational indicators (e.g., ear piece, speaker, LED, backlighting, etc.).

j. Assessment results of the compatibility and adaptability of operator when using personal protection equipment and tactical mission apparel (e.g., MOPP and NBC gear, gloves, back packs, ammo vests, head protection, goggles, etc.).

k. Assessment of human/machine interface correlating to hardware design and ease/difficulty in operational use.

l. Record the duration operators are scanning with the SUT between breaks, and if applicable, the duration of rest periods.

m. Record and summarize the questionnaire/interview results.

5.10 Electromagnetic Environmental Effects (E3) and Vulnerability.

a. Results of E3 tests performed as screening tests separate from field trials (E3 radiated emissions, compatibility, interference, conducted emissions, radiated susceptibility, etc).

b. Identify any vulnerabilities or susceptibilities of equipment to RF frequency intrusion (deliberate or unplanned).

c. Identify any vulnerability to natural phenomena (lightning, electrostatics).

d. Identify susceptibilities to common battlefield RF.

e. Determine minimum separation distance between two detectors or detection-systems before detectors start to interfere (electromagnetic interference) with each other.

5.11 Software.

a. Record of software version at start of system performance trials.

b. Record of problems attributable to software related to system diagnostics or system performance.

c. Identify and record software revisions during testing and when during testing it was changed.

d. Document at software version at the end of testing.

6. PRESENTATION OF DATA.

a. All raw test data must be recorded and retained for a specified period after the test. This data will not necessarily be presented but must be available to verify the test results if there are subsequent queries.

b. The results of the test should be recorded in a Test Report. The method of presenting and the level of detail presented will be directed by the authority for whom the trial is being conducted but, as a minimum, should include:

(1) Descriptions of the inspection, specific test procedures, and results for each SUT using narration, tables, photographs, charts, and graphs as appropriate.

(2) Diagrams and photographs (as necessary) to show the type of container (when applicable), type of carrier (attachable equipment only), configurations of the SUT (e.g., stowing, assembled, disassembled, etc.), and to document any damage.

(3) Performance scoring is presented in tabular tables presented by various parameters. The analysis of the data collected should include scores, results, and any other relevant assessments. Detector performance should be analyzed though the scoring of performance of detection and fails alarm rate, and ROC curves (see Appendix G). Performance must also be broken into several categories, e.g., by target type, depth, operator, mode of detection, lane number, etc. The scoring must include a study/comparison of the difference in performance of any different systems/platforms as determined by target types and depths.

(4) Summary of results should include a description of the performance of missions with respect to encounters, performance of detection, alarm rates, advance rate, and failures. Reliability indices such as operational run times, maintenance ratios, and availability of equipment should be computed.

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APPENDIX A. FREQUENCY ALLOCATION FORM.

FREQUENCY ALLOCATION INFORMATION REQUIREMENTS		
(1)	Name of Program	
(2)	Purpose of Program	
(3)	Security Classification	
(4)	Frequency	
(5)	Transmitter Power (Watts)	
(6)	Time of Usage	
(7)	Required Start and End Dates	
(8)	Transmitter Nomenclature	
(9)	Transmitter Location	
(10)	Transmitter Antenna Data	(a) Type/Name (b) Gain (c) Site Elevation (d) Antenna Feedpoint Height (e) Orientation (f) Polarization
(11)	Receiver Nomenclature	
(12)	Receiver Location	
(13)	Receiver Antenna Data	(a) Type/Name (b) Gain (c) Site Elevation (d) Antenna Feedpoint Height (e) Orientation (f) Polarization
(14)	J/F-12 Number (if assigned)	
Reference: Spectrum Management Office (SMO) Data Requirements AR 5-12, Army Management of the Electromagnetic Spectrum Oct 1997 DD Form 1494 Preparation Guide		

Figure A-1. Typical frequency allocation request form.

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APPENDIX B. DOCUMENT REVIEW CHECKLIST.

B.1. ATEC TEST CHECKLIST (reference DA PAM 73-1).

In order to properly assess the safety, performance, and reliability of the SUT, a pre-planning detailed review must be conducted. This review ensures a proper overview of required administrative and safety protocols are emplaced prior to initiation of testing. The following documents should be included in the test item data package; it is preferable that these documents be provided as early as possible prior to the start of testing.

a. Safety Assessment Report.

b. Health Hazard Assessment Report.

c. All test data available regarding the item requiring the Safety Release. If no current test data are available, any other information that can be used (for example, prior Government test data, contractor test data), with the emphasis on safety data.

d. Environmental documentation (record of environmental consideration (REC)).

e. Training plans.

f. Equipment technical/operator publications.

g. Mission scenario/mission profile.

h. Test Plan.

i. Test and Evaluation Master Plan.

j. Frequency Allocation Documentation.

k. Software Requirements Specification.

l. U.S. Army Institute of Public Health Command Study (laser, radiofrequency radiation, and/or ionizing radiation).

m. System Requirements Documents.

n. Security Classification Guide, and Operations Security (OPSEC) document.

o. Source of troops involved in developmental and operational testing.

p. Test Readiness Review.

APPENDIX B. DOCUMENT REVIEW CHECKLIST.

NOTE: When sufficient data are not available on which to base a Safety Release or complete safety review, additional testing may be necessary. In such cases, required testing will be performed by the testers, and test costs will be paid by the materiel developer or SUT customer.

B.2. TEST AND EVALUATION SUBTEST OVERVIEW.

Table B-1 provides a summary list of test and evaluation subtests that should be considered when designing a comprehensive hand-held detector assessment. Time, cost, and SUT resources determine feasibility of execution for any specific test acquisition phase.

TABLE B-1. TEST AND EVALUATION SUBTEST SUMMARY

SUBTEST	REFERENCE TEST PROCEDURE (S)	DESCRIPTION
Inspections		
Preliminary Inspection		Provides inspection and baseline operation prior to initiation of testing. Ensures test item is safe and ready to initiate testing.
Physical Characteristics		Determines dimensions and other physical characteristics of the test.
Final Inspection		Provides inspection and baseline operation following completion of testing
Performance		
Software Performance	ITOP 01-1-056[9]	Used to evaluate a system's software functional capabilities. It does not specifically address other software-related issues, such as safety or security. The method for undertaking the software performance assessment discussed in this document addresses software T&E as an integral element of system T&E and is targeted at the system performance level. Key elements of this approach include the allocation of system requirements to software, assessment of software performance, and assessment of the impact of software on overall system performance.
Detection Sensors - metal - GPR - Infrared		Validates the adequacy and accuracy of detection system sensors.

APPENDIX B. DOCUMENT REVIEW CHECKLIST.

TABLE B-1. CONTINUED

SUBTEST	REFERENCE TEST PROCEDURE (S)	DESCRIPTION
Logistics		
Logistics Supportability		Determines the logistic supportability of the test item through quantitative and qualitative analysis of the test item.
Reliability, Availability, Maintainability		Quantitative analysis of data collected during endurance testing in order to determine the overall ability of the system to complete tasks.
Technical Manuals		Determines adequacy and accuracy of provided system technical manuals.
BIT/Built-In Test Equipment (BITE) Embedded Diagnostics		Used to evaluate system particular test, measurement, and diagnostic equipment. This test also takes into consideration not only the interface between the test equipment and the system, but also the interface between the test equipment and other elements of the planned maintenance support such as manuals, repair parts, common test equipment and tools, and calibration facilities, etc.
Safety/Software		
System Safety	TOP 01-1-060[10] TOP 02-2-508[11]	Used to identify and evaluate hazards associated with test items. Testing will provide determination or assessment of personnel and equipment hazards in the system and associated operation and maintenance hazards.
Critical Software Analysis and Testing	ITOP 01-1-057[12]	Describes the activities necessary to ensure that safety is designed into software that is acquired or developed and that safety is maintained throughout the software life cycle. It provides uniform procedures for developing and implementing a safety-critical software test methodology of sufficient comprehensiveness to identify the software caused hazards of a system and to impose design requirements and management controls to prevent mishaps. The objective is to ensure that the software design takes positive measures to enhance system safety, and that software errors which could reduce system safety have been eliminated or controlled to an acceptable level of risk.

APPENDIX B. DOCUMENT REVIEW CHECKLIST.

TABLE B-1. CONTINUED

SUBTEST	REFERENCE TEST PROCEDURE (S)	DESCRIPTION
Human Machine Interface		
Human Factors	TOP 01-2-610[13]	Used to provide human factors engineering assessment of equipment.
Noise Levels	MIL-STD-1474D[14] DA PAM 40-501[15]	Used to determine operating noise levels.
Environmental		
Environmental Performance - High Temperature - Low Temperature - Solar Radiation - Rain - Humidity - Fungus - Salt Fog - Sand and Dust - Icing/Freezing Rain - Vibration	MIL-STD-810G	Determines the operating, maintenance, and durability characteristics the detection system when operating in extreme environments.
E^3		
EMI/EMC - Radiated Emissions - Radiated Susceptibility - Hazards of Electromagnetic Radiation to Ordnance (HERO) - Hazards of Electromagnetic Radiation to Fuel (HERF) - Hazards of Electromagnetic Radiation to Personnel (HERP) - Helicopter Electrostatic Discharge (HESD) - Personnel Electrostatic Discharge (PESD) - High Altitude Electromagnetic Pulse (HEMP) - Near Strike Lightning - Bonds and Grounds - Conducted Susceptibility - Conducted Emissions - Intra-system EMC	TOP 01-2-511A[16]	Determines whether the item tested meets the electromagnetic radiation effects, static electricity, and lightning criteria and the maximum electromagnetic radiation environment to which the test item may be exposed without adverse effects. Ensures that the equipment under test is able to operate in its intended electromagnetic environment without its performance being degraded and without degrading the performance of other system(s) in close proximity

APPENDIX B. DOCUMENT REVIEW CHECKLIST.

TABLE B-1. CONTINUED

SUBTEST	REFERENCE TEST PROCEDURE (S)	DESCRIPTION
Electromagnetic Interference/Compatibility		
Interference	MIL-STD-461F[17]	Provides verification requirements for the control of the electromagnetic interference (emission and susceptibility) characteristics of electronic, electrical, and electromechanical equipment and subsystems.

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APPENDIX C. SUPPLEMENTAL PLANNING AND RANGE CHARACTERIZING.

C.1. SUPPLEMENTAL PLANNING.

This appendix contains outline examples that can aid in the organization of those processes associated with planning and execution of trials associated with detection testing. Development of the scope of the trials as well as logical organization of data collection is critical to an orderly examination of any technology. Table C-1 lists examples of threat target types that may be used for detection assessment trials. Figure C-1 shows a typical target characterization data form.

TABLE C-1. DETECTION THREAT TARGET TYPES

TARGET	CATEGORY / DESCRPTION
Mines	Anti-tank metallic (AT-M)
	Anti-tank low metallic (AT-LM)
	Antipersonnel low metallic (AP-LM)
	Antipersonnel metallic (AP-M)
IED Arrays (complete system)	None
IED Component – Pressure Plates	- Low Metal Pressure Plates (LMPP); - No Metal Pressure Plates (NMPP); - High Metal Pressure Plate; - Fuzing Devices: Low metallic pressure plates (carbon core, tire), non-metallic pressure plates (fence post, double plunger), lamp cord, and enamel coated copper wire.
IED Component – Main Charges	- No Metal Main Charge (NMMC): Ammonium nitrate-filled plastic jug (non-metallic), ammonium nitrate-filled plastic pail (non-metallic); mine. - Metal Main Charge (MMC): mine and ammonium nitrate-filled pressure cooker (metallic).
IED Component – Other	command wire
Clutter	manmade and natural (metallic and non-metallic)

NOTE: Included in any target set, the emplacement of clutter must be considered to simulate urban environmental ground conditions the detection systems may be exposed to during a clearance mission. Clutter types for this test are categorized as metallic or nonmetallic. All targets are buried at standardized depths for that specific target category.

APPENDIX C. SUPPLEMENTAL PLANNING AND RANGE CHARACTERIZING.

YTC CMINE TARGET CHARACTERIZATION DATA SHEETS

	Munition Id	Nomenclature	Mine Charge	Booster	Detonator	Original Data	Remarks	Burial Depth	TAG	Placement	Lane	Location
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												

File Name: Target Characterization_FORM_DEC06
Work Sheet: SAMPLE M15-72W

Inspected By:

Page 1 of 1

Figure C-1. Typical target characterization data form.

APPENDIX C. SUPPLEMENTAL PLANNING AND RANGE CHARACTERIZING.

C.2. TEST LANE CHARACTERISTICS.

a. Table C-2 provides examples of soil and topography characteristics.

TABLE C-2. EXAMPLES OF SOIL/TOPOGRAPHY CHARACTERISTICS FOR TRIALS

SOIL PROPERTIES	SOIL TYPE – UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)		
	Clayey Sand (USCS Type SC)	Clay of Low Plasticity (USCS Type CL)	SILT (USCS Type ML)
Surface roughness			
Smooth (< 5 cm)			
Medium (< 10 cm)			
High (> 10 cm)			
Contamination			
Metal content			
Ferrous			
Non-ferrous			
Water content			
< 5%			
< 10%			
> 10%			
Rocks			
< 7 cm			
> 7 cm			
Debris			
< 7 cm			
> 7 cm			

NOTE: Develop a table for soil classifications required for the application. Prioritize those soil types from highest to lowest probability of encounter. Select trials sites based upon that examination to provide a broad, but representative sampling of soil conditions relevant to the examination. The soil considered for the tests could be different types, according to the principal component (sand, clay or silt). In this way we satisfactorily cover a wide range of realistic significant cases for soil conditions. For a better understanding of soil properties, the test team should investigate expertise existing on site, leverage existing soil topographical and soil surveys of sites, and/or confirm soil types and topography through a pre-trials survey. Where possible, universal or uniform soil classifications should be used in conjunction with a narrative description of the soils to permit comparison with other trials.

APPENDIX C. SUPPLEMENTAL PLANNING AND RANGE CHARACTERIZING.

b. This is an example of a descriptive write up without detail soil characteristics data:

The Detection System X will perform the detection phase on test lanes at the Countermine Testing and Training Range (CTTR), in the Sonoran Desert of Arizona. The Detection System X off route detection blind test lanes consisted of 1.5-meter wide and 50-meter long test lanes. They are constructed on dirt trial over flat terrain and traversing in and out of wash beds (wadi). The lanes are categorized as calibration, data collection, blind, and excursion.

APPENDIX D. SUPPLEMENTAL DATA REQUIREMENTS AND FIELD DATA SHEETS.

D.1. FIELD DATA SHEETS.

Figures D-1 and D-2 are examples of typical field data collection sheets.

Detector Data Sheet

RUN Number________________ DATE: ________________________

OPERATOR ________________ Lane: ______________ DATA COLLECTOR: ______________________

Detector SERIAL NUMBER: ____________

ENVIRONMENTAL CONDITIONS: ☐ Sunny ☐ Hot ☐ Nice ☐ Cold ☐ Windy ☐ Dusty ☐ Overcast ☐ Rain ☐ Night

Other: ____

START TIME: __________ FINISH TIME: __________ BREAK TIME: __________ ELAPSED TIME: __________

Poker Chip Targets = Blue/Red Clutter = White		**Alarm/Sensor Modality** (check as many that apply)				**Comments**
Number	**Color**	**MD**	**PENTAD**	**IED**	**WIRE**	

SAFETY AND HUMAN FACTORS OBSERVATIONS **(X on selected number; comments as needed and on back)**

- Scanning Comfort Scale: Extreme Discomfort ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ Comfortable

  If Less than 7 explain, why: ____

- Operational Use:

  ☐ Earpiece ☐ Loud Speaker Sound Level Low ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ High

  ☐ LED Visual Illumination Level Poor ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ Great

  ☐ Disassembly ☐ Assembly Difficult ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ Easy

  If Less than 7 explain: ____

- Data Collector's Observations of Operator Or Safety Issues: ____________________

____

Page _____ of _____

Figure D-1. Example of a field data collection sheet.

APPENDIX D. SUPPLEMENTAL DATA REQUIREMENTS AND FIELD DATA SHEETS.

BATTERY MONITORING DATA SHEET

Detector (Unit: ___)

Battery SN	Date On	Time On	SOC ON (1-4/ 2-5)	Time Off	SOC OFF (1-4/ 2-5)

Legend: SOC -- State of Charge (if dispayed)

Figure D-2. Example of a field data collection sheet.

APPENDIX D. SUPPLEMENTAL DATA REQUIREMENTS AND FIELD DATA SHEETS.

D.2. OVERVIEW OF FIELD DATA CONSIDERATIONS.

Table D-1 shows typical Mission or Trial Information.

TABLE D-1. SYSTEM PERFORMANCE TRIALS DATA REQUIREMENTS

DATA ELEMENTS	FOOTNOTES
1. Administrative Data	
1.1 Trial (or Mission) ID number	
1.2 Trial (or Mission) Date	
1.3 System ID number	
1.4 Platform ID number (if vehicle platform)	
1.5 Test Player ID number	
1.6 Test Player Team ID number (if teams of individuals are used); list ID numbers of all test players on team	
1.7 Test Player Equipment, Clothing, and Accessories (as appropriate, for collation to human factors appraisal) • Clothing (Army Combat Uniform (ACU), Cold Weather clothing, or Mission Oriented Protective Posture (MOPP) level) • Accessories (Night Vision Goggles, Protective Glasses or Masks, Radios, etc)	
1.8 Data Collector ID number	
2 Mine/Test Target Data	
2.1 Target ID Number (ITOP 04-2-521, paragraph 5.a)	
2.2 Target Location (ITOP 04-2-521, paragraph 5.b)	
2.3 Target Burial Depth (ITOP 04-2-521, paragraphs 5.c and 5.d)	
2.4 Target Orientation (ITOP 04-2-521, paragraph 5.e)	
2.5 Target Weathering Data (ITOP 04-2-521, paragraph 5.f)	
2.6 Target Emplacement Technique (ITOP 04-2-521, paragraph 5.g)	
2.7 Target Characteristics and Features (ITOP 04-2-521, paragraph 5.i)	
2.8 Other Target Information (ITOP 0 4-2-521, paragraph 5.j)	
3 Target Lane Array Data	
3.1 Mine Lane ID number; List target ID numbers of all mines within lane	

APPENDIX D. SUPPLEMENTAL DATA REQUIREMENTS AND FIELD DATA SHEETS.

TABLE D-1. CONTINUED

DATA ELEMENTS	FOOTNOTES
3.2 Geodetic plots and x-y position spreadsheets of all mines/targets within lane	
3.3 Overlay of Mine Lane ID numbers on respective lane ID numbers	
3.4 Updated plots and position spreadsheets if deliberate changes are made to a Lane ID, such as planned disturbance or addition of detritus (battlefield trash or other objects)	
3.5 Description and location of any combat obstacles used in conjunction with Lane/Target Arrays (ITOP 04-2-521, paragraph 5.h)	
4 Meteorological Data (regardless of whether natural conditions or artificially developed conditions) on inter-range instrumentation group (IRIG) basis collated with Trial or Mission ID number(s)	
4.1 Air Temperature	
4.2 Precipitation - Duration - Intensity - Accumulation - Phase (rain, snow, etc).	
4.2 Wind - Speed - Direction	
4.3 Barometric Pressure	
4.4 Relative humidity	
4.5 Ground Temperature	
4.6 Solar Loading	
4.7 Cloud cover, height	
4.8 Light level	
5 Soil Data (for all lane ID numbers)	
5.1 Geodetic plot of soil survey measurement points and tabulation of classification and characterization by measurement points.	

APPENDIX D. SUPPLEMENTAL DATA REQUIREMENTS AND FIELD DATA SHEETS.

TABLE D-1. CONTINUED

DATA ELEMENTS	FOOTNOTES
5.2 Type of soil and soil classification/sampling system or method used to characterize: a. Metal content b. Soil composition c. Soil texture d. Rock distribution e. Surface roughness f. Electrical properties (conductivity, dielectric constant, etc.) g. Magnetic properties (frequency dependence) h. Thermal properties (conductivity, diffusivity, temperature, emissivity, density, specific heat) i. Clutter (natural and man-made; magnetic and non-magnetic; roots, holes, wood, plastic, unusual soil/overburden stratification's and discontinuities). If clutter is placed as a target document IAW ITOP 04-2-521 and Mine/Test Target Data requirements.	
5.3 Moisture content and method used to characterize moisture. Description of any method used to control moisture.	
5.4 Other ground truth data unique to the environment, detector type or detector platform (such as vehicle speed/position, radiometric temperatures of backgrounds and/or calibration targets).	
6 Vegetation/Terrain Data	
6.1 Narrative description, photographs, and physical surveys of terrain and vegetation	
7 Mission Data (for each Trial or Mission ID number)	
7.1 Start Time	
7.2 Stop Time	
7.3 Start Point (Geodetically Marked)	
7.4 Geodetic Path and Swath Path in Lane	
7.5 Stop Point (Geodetically Marked)	
7.6 Alert Number	
7.7 Time of Alert	
7.8 Alert Status (Initial Alert, Continue, Disappear)	
7.9 Detection Point for Alert (Geodetically Marked)	

APPENDIX D. SUPPLEMENTAL DATA REQUIREMENTS AND FIELD DATA SHEETS.

TABLE D-1. CONTINUED

DATA ELEMENTS	FOOTNOTES
8 Sensor Experimentation Testing Data	
8.1 See 2.1 through 2.7 for common data requirements. Although not all may applicable, these will provide a framework for collection.	
8.2 Description of test setup to include construction materials of soil bins, special apparatus (if used) to control detector position (x, y, z), detector advance or sweep rates, and detector angular displacement.	
8.3 Performance and Performance Analysis. Provide IAW Appendix C.	
9 Sensor Verification Testing Data	
9.1 See 2.1 through.7 for common data requirements. Although not all may be applicable, these will provide a framework for collection.	
9.2 Performance and Performance Analysis. Provide IAW Appendix C.	
10 Lane Testing Data	
10.1 See 5.2.1 through 5.2.7 for common data requirements.	
10.2 Performance and Performance Analysis. Provide IAW Appendix C.	
10.3 Measure or analysis of the likelihood of a mine fuse being initiated by the detection equipment	

APPENDIX E. HUMAN FACTORS SAMPLE SURVEYS.

Trials Information

a.	Date			c.	Test Player ID	
b.	Trial ID			d.	System ID	

INSTRUCTIONS

This form is the operator's opportunity to provide feedback about the unit and system. Any comments made will be helpful in developing a system that will perform its mission safely and effectively, and without placing undue stress or hardship on the system operator.

The operator is asked to evaluate each item on this form and give a rating from 1 to 5, with the higher numbers being an easier/more comfortable/better score. Room is available on the last page for explanatory comments. The operator is requested to explain every 1 or 2 rating; any other comments are also helpful.

1. System Operation

a. Assembly:

1 2 3 4 5

Difficult Not difficult

b. Operation:

1 2 3 4 5

Difficult Not difficult

c. Alerts:

1 2 3 4 5

Could not understand Easily understood

Figure E-1. Human Factors sample survey.

APPENDIX E. HUMAN FACTORS SAMPLE SURVEYS.

d. Understanding display:

1	2	3	4	5
Difficult				Not difficult

e. Changing batteries:

1	2	3	4	5
Difficult				Not difficult

2. Manpower and Personnel Integration (MANPRINT)/Human Factors/Ergonomics

(1) Helmet:

1	2	3	4	5
Uncomfortable				Comfortable

(2) Backpack:

1	2	3	4	5
Uncomfortable				Comfortable

(3) Holding wand:

1	2	3	4	5
Uncomfortable				Comfortable

(4) Moving wand repeatedly:

1	2	3	4	5
Uncomfortable				Comfortable

Figure E-1. Human Factors sample survey.

APPENDIX E. HUMAN FACTORS SAMPLE SURVEYS.

(5) Audio tones:

1	2	3	4	5
Harsh				Comfortable

(6) Display:

1	2	3	4	5
Hard to Read				Easy to read

(7) Controls:

1	2	3	4	5
Difficult				Not Difficult

3. Other

(1) Manuals and documentation:

1	2	3	4	5
Hard to follow				Complete, useful

(2) Safety during operations:

1	2	3	4	5
Operator is not safe				Operator is safe

(3) Built In Test (BIT):

1	2	3	4	5
Difficult or incomplete				Easy and complete

Figure E-1. Human Factors sample survey.

APPENDIX E. HUMAN FACTORS SAMPLE SURVEYS.

(4) Daily PMCS:

1	2	3	4	5
Difficult or incomplete				Easy and complete

4. Comments

Item: ___

Comment:	

Item: ___

Comment:	

Figure E-1. Human Factors sample survey.

APPENDIX E. HUMAN FACTORS SAMPLE SURVEYS.

Human Factors Questionnaire:

1) Ease of System Operation.

2) Ease of use and functionality of audio/visual displays

3) Clarity and distinction of audio/visual alerts

4) Where the controls performance indicators legible.

5) Ease of operator troubleshooting and repairs.

6) Ease of the system transport in carrying case, assembly of system, and transport of assembled system.

7) Fit and comfort of components. Include comments on ease of performing normal tasks, ability to adjust fit of components to operators of different body dimensions, and ease of time required for removal of components.

8) Any difficulties encountered in performing any mission task due to mission-required clothing or equipment.

9) Was the information in the Operations Manual adequate in providing instructional guidance on the operation and maintenance of the system?

Figure E-1. Human Factors sample survey.

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APPENDIX F. EXCURSION TRIALS CONSIDERATIONS.

This Appendix provides sample guidance on procedures that may be used in the detectability performance testing of detection equipment for countermine and demining equipment (handheld dismounted detection sensors) for Excursion trials.

F.1. LIMITATIONS.

a. This Appendix provides a narrative outline for testing of portable or handheld detection equipment using magnetic induction and GPR sensors. With review and/or slight modification this guidance may also be suitable for vehicle mounted detection systems and detection systems using IR or other sensors.

b. The information provided is for testing detection equipment in Sensor Experimentation Facilities. With review and/or slight modification this guidance may also be suitable for testing in sensor verification areas or target lanes.

F.2. TESTING OBJECTIVES.

a. Testing objectives will impact on the test design. Some examples of testing objectives are as follows:

(1) To benchmark system or subsystem performance.

(2) To determine if a change to equipment design has improved performance.

(3) To determine what piece of equipment performs better.

(4) To determine if a piece of equipment meets minimum performance characteristics.

(5) To determine with a very high degree of confidence the exact performance capabilities of the equipment.

(6) Quality control/sampling type testing.

b. Test objectives will impact on what test data should be collected and number of data points required to achieve the desired degree of statistical confidence.

APPENDIX F. EXCURSION TRIALS CONSIDERATIONS.

F.3. <u>EXCURSION TESTING</u>.

F.3.1 <u>Excursion Sensing Envelope Testing</u>.

Record equipment response when passing directly over a surface emplaced target at the manufacturers recommended head operating height. Repeat test passing at increasing offset distances from the target centerline until the target is no longer detectable. Increase distances from the target centerline in either 2 or 4 cm increments. For non-symmetrical targets repeat testing along other target axis's. Repeat testing with different size targets and/or targets containing different amounts of metal.

F.3.2 <u>Excursion Target Depth Testing</u>.

Record equipment response when passing directly over a surface emplaced target at the manufacturers recommended head operating height. Repeat test with the same target at increasing burial depths recommended in ITOP 04-2-521 until the target is no longer detectable. Repeat testing with different size targets and/or targets containing different amounts of metal.

F.3.3 <u>Excursion Target Size Testing</u>.

Record equipment response when passing directly over a surface emplaced target at the manufacturers recommended head operating height. Repeat testing with different size targets and/or targets containing different amounts of metal until the target is no longer detectable. Repeat testing at increasing burial depths recommended in ITOP 04-2-521.

F.3.4 <u>Test Excursions</u>.

Conduct the above tests with changes to the following variables:

a. Different head/antenna operating heights and tilts.

b. Faster or slower sweep velocities.

c. Wet detector heads/antennas (mist or immersion).

d. Batteries in varying state of charge.

e. Time or temperature effect on sensitivity drift/stability.

f. Different sensitivity or control settings on the equipment under test.

APPENDIX F. EXCURSION TRIALS CONSIDERATIONS.

F.3.5 Soil/Overburden.

F.3.5.1 Soil Type Selection.

Depending on the type of equipment under test, repeat above testing with different type soils. At a minimum consider the following or similar type soils:

a. Dry sand.

b. Wet clay/loam.

c. Magnetite sand (30%).

F.3.5.2 Soil Conditions.

Consider testing in soils ranging from very dry to those completely saturated from high water table conditions. Consider that some detection equipment may be required to operate in soil with high levels of salts. Soil moisture may be non-homogeneous. Natural or artificial ice/snow can be placed on the soil. The soil may be frozen ranging from just a few centimeters to far below the test targets. The soil surface can be misted or soaked to simulate conditions shortly after a rainfall. Consider that the degree of soil surface roughness can strongly influence the performance of some GPR sensors. Consider that the detection system may have to operate on unimproved roads that may be gravel rather than soil. Consider that the soil may support vegetation.

F.3.5.3 Soil/Overburden Clutter.

Clutter is an object or feature that interacts with a detection sensor in a way similar to or identical to a mine. Clutter can be that naturally existing at the test area or emplaced there just for test purposes. Clutter can be natural or manmade. Clutter location, like target location, can be documented. However if the test site selected is left undisturbed this creates a dilemma in that the natural clutter location might have to be determined using various detection sensors. Clutter includes pieces of magnetic and non-magnetic metal, roots, holes, rocks of various composition and size, unusual soil/overburden stratifications and discontinuities, wood, plastic, etc. The discrimination of mines from clutter is perhaps the most challenging component of effective detection system design.

APPENDIX F. EXCURSION TRIALS CONSIDERATIONS.

F.3.5.4 Soil Condition/Clutter Selection.

The ratio of probability of detection to false alarms rates (Pd/FAR) is frequently used as the final measure of detection system performance. This ratio is primarily dependent on the detection equipment capability, its sensitivity settings, the type, number and emplacement of targets in the test area, the soil or overburden, the considerations in paragraph 2.4, and the clutter. To systematically address these variables it is recommended that detection equipment performance first be tested and baselined in homogenous soil conditions (without clutter or any property stratification). Keep the surface soil smooth and without vegetation or clutter. Address equipment performance and test excursions (paragraph 2.4) in different soil types and moisture conditions before introducing other conditions or variables.

APPENDIX G. DETECTION SCORING.

G.1 SCORING FOR DETECTION AND FALSE ALARMS.

a. Using the alarm files of potential target locations are either matched to an emplaced target and called "detection," or not matched to a target and considered a "false alarm." Declarations are matched to an emplaced target if the declaration is within a critical distance, Rhalo, of the edge of the target. The value of Rhalo is determined through the analysis of the distances between all of the alarm declarations and the true target locations from the ground truth, not a value designated prior to testing. This is called a "miss distance" analysis.

b. This distance criterion can result in more than one candidate declaration that matches a particular emplaced target. When there are redundant declarations within the Rhalo, the operator is credited with a single detection of the target. Redundant detections are not counted as false alarms. If a declaration is not within Rhalo of any emplaced target, and is located within the test lane, then that declaration is considered a false alarm.

c. The *Pd* and *FAR* are the two primary measures derived from a blind test. The detection probability is simply the fraction of the encountered targets that are detected by the operator(s).

d. This probability is computed for each target category as well as for each target type. This number reflects a "point estimate" of the probability of detection. 90% confidence intervals based on the binomial distribution will be calculated for all Pd's.

e. The FAR is the measure of the number of false alarms per square meter of operation for the detector. Opportunities for false alarms occur in the area of the test lane that does not include the area covered by the targets and the region defined by their Rhalo, that is: test lane area - area of targets within Rhalo.

f. Figure G-1 shows a conceptual scoring example showing alarm markers, target halos, and targets, to include detections, redundant detections, and false alarms.

APPENDIX G. DETECTION SCORING.

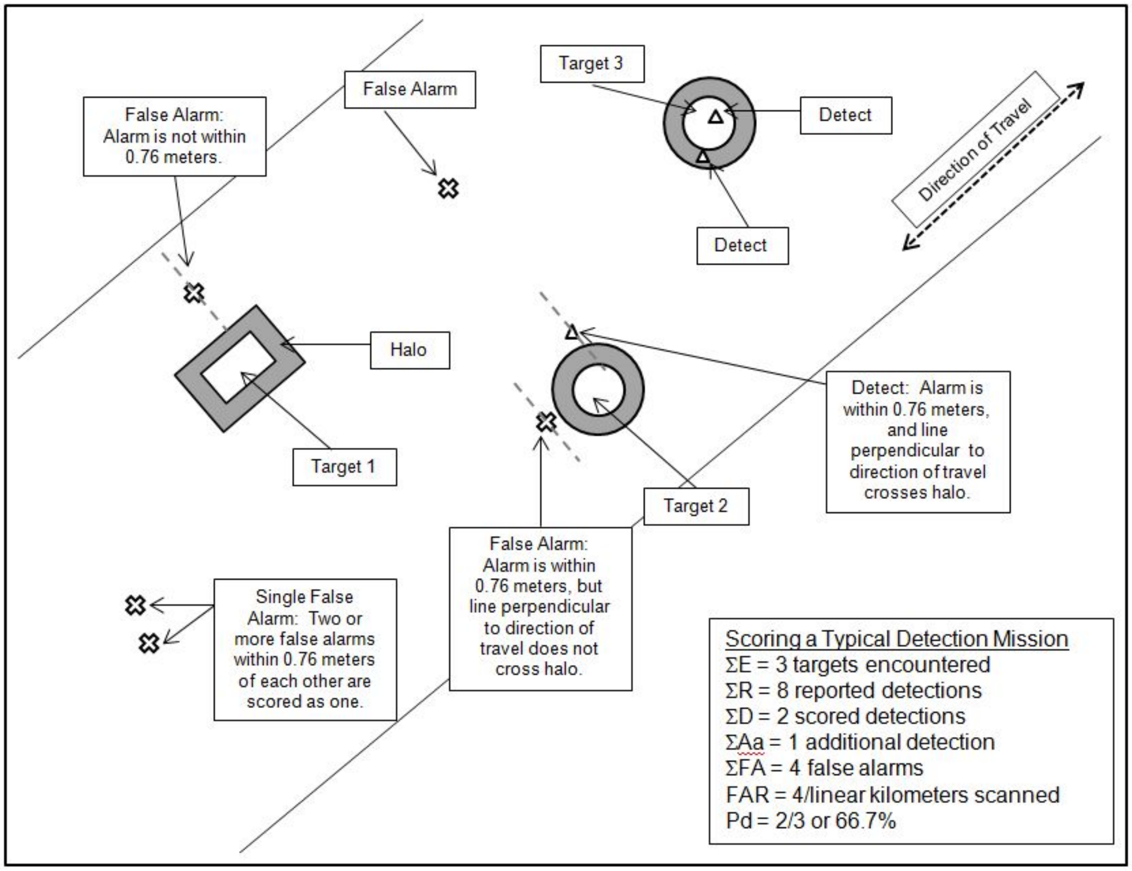

Figure G-1. Performance detection scoring and assessment example.

g. Performance detection scoring calculation formulas are as follows:

$$PD = \Sigma D / \Sigma E$$
$$Aa = \Sigma(A - D)$$
$$\Sigma FA = \Sigma R - \Sigma A$$
$$FAR = \Sigma FA/\text{length}$$

Where
- E = an encounter of a target
- R = a reported alert
- A = a reported alert within the required accuracy
- D = a single, "scored" accurate alert for a single encounter
- Aa = number of additional accurate alerts
- FA = false alarm; a reported alert outside the allowed accuracy of any target
- FAR = false alarm rate; the sum of FAs per length searched.

APPENDIX G. DETECTION SCORING.

G.2 RECEIVER OPERATING CHARACTERISTIC (ROC) CURVES.

a. The Pd is the probability of saying that "1" is true given that event "1" occurred. The Pfa is the probability of saying that "1" is true given that the "0" event occurred. In applications such as sonar and radar, the "1" event indicates that a target is present, and the "0" event indicates that a target is not present.

b. A detector's performance is measured by its ability to achieve a certain probability of detection and probability of false alarm for a given SNR. Examining a detector's ROC curves provides insight into its performance. We can use the rocsnr function to calculate and plot ROC curves.

c. One feature of the rocsnr function is that you can specify a vector of SNR values and rocsnr calculates the ROC curve for each of these SNR values. Instead of individually calculating Pd and Pfa values for a given SNR, we can view the results in a plot of ROC curves. The rocsnr function plots the ROC curves by default if no output arguments are specified. Calling the rocsnr function with an input vector of four SNR values and no output arguments produces a plot of the ROC curves.

d. In the plot (Figure G-2) we can select the data cursor button in the toolbar (or in the Tools menu) and then select the SNR = 8 dB curve at the point where Pd = 0.9 to verify that Pfa is approximately 0.01.

APPENDIX G. DETECTION SCORING.

```
SNRvals = [2 4 8 9.4];

rocsnr(SNRvals);
```

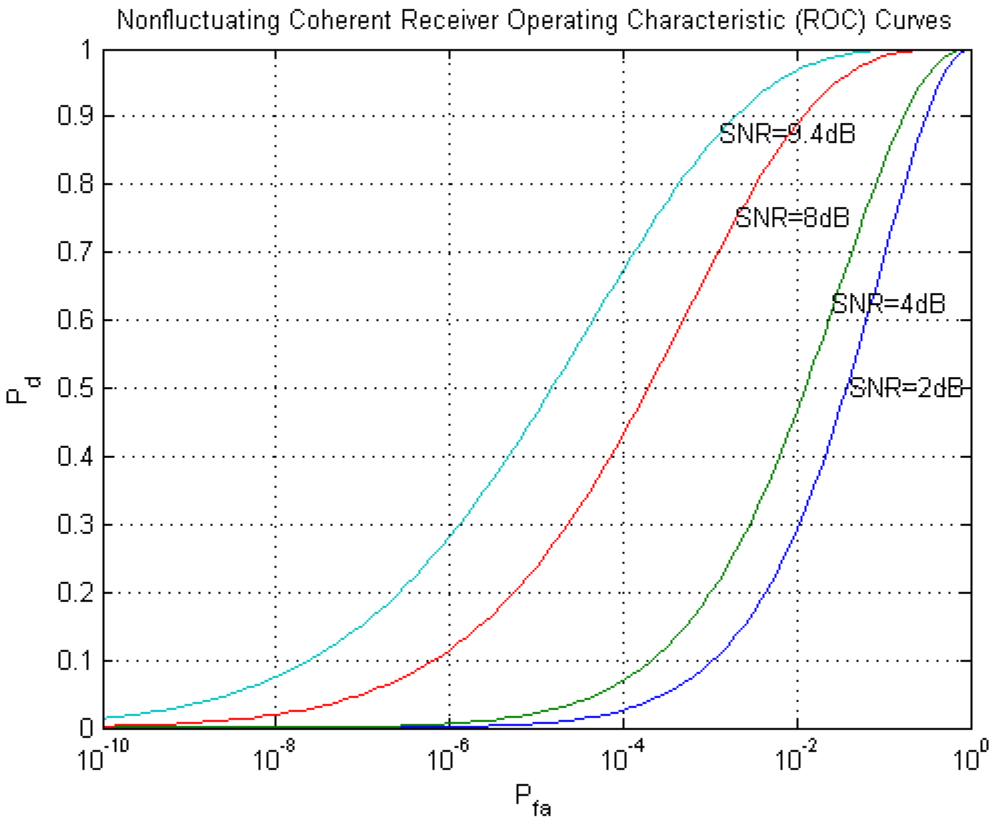

Figure G-2. ROC curve.

G.3 <u>MULTIPLE PULSE DETECTION</u>.

a. One way to improve a detector's performance is to average over several pulses. This is particularly useful in cases where the signal of interest is known and occurs in additive complex white noise. Although this still applies to both linear and square-law detectors, the result for square-law detectors could be off by about 0.2 decibel (dB). Let's continue our example by assuming an SNR of 8 dB and averaging over two pulses.

APPENDIX G. DETECTION SCORING.

b. By inspecting the plot (Figure G-3) we can see that averaging over two pulses resulted in a higher probability of detection for a given false alarm rate. With an SNR of 8 dB and averaging over two pulses, you can constrain the probability of false alarm to be at most 0.0001 and achieve a probability of detection of 0.9. Recall that for a single pulse, we had to allow the probability of false alarm to be as much as 1% to achieve the same probability of detection.

```
rocsnr(8,'NumPulses',2)
```

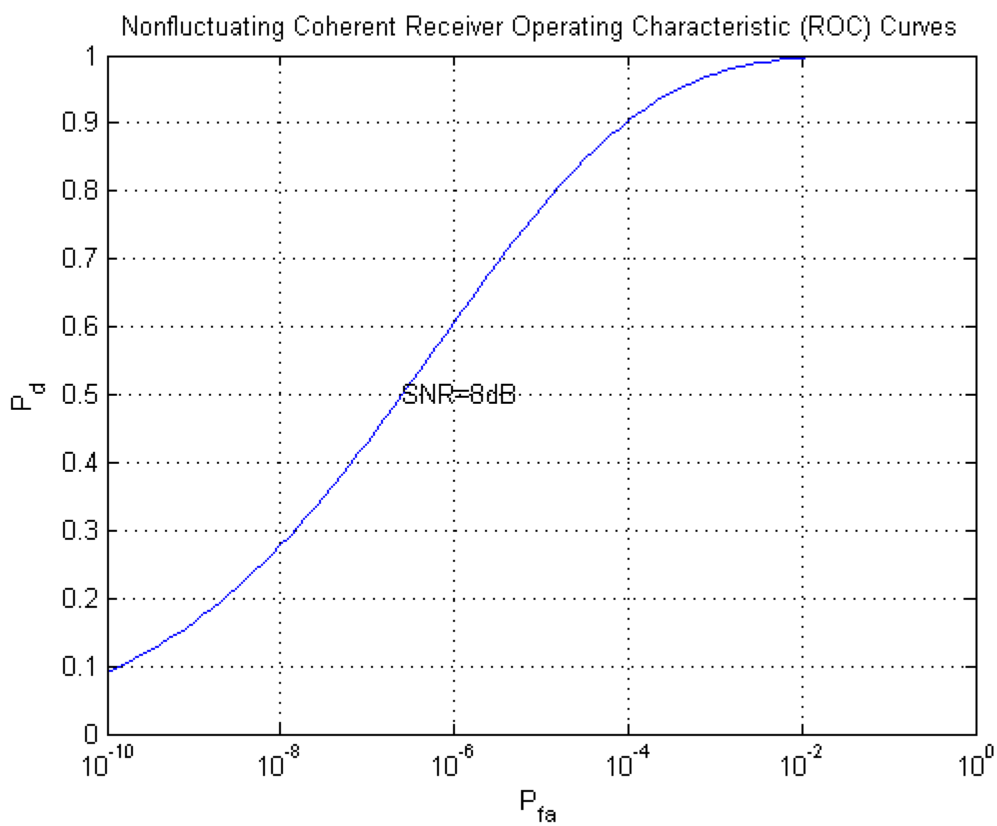

Figure G-3. ROC curve.

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APPENDIX H. DATA SECURITY CLASSIFICATIONS.

H.1. The data detection performance results from formal testing of mature system design configurations are classified as specified below.

a. Statements regarding quantitative defeat performance at specific (quantitative) depths against specific models of U.S. landmines are SECRET. Statements regarding performance against generic U.S. landmine types (e.g., simulators or surrogates) or generic depths (e.g., shallow or deep) or statements in which the system is not identified (unless it is identified in the larger context of a document) are UNCLASSIFIED. Examples are as follows:

(1) SECRET: Name of SUT True Name defeats XX% of specific U.S. landmine nomenclature at specific depths.

(2) UNCLASSIFIED: Name of SUT defeats XX% of specific U.S. landmine nomenclature at generic depths.

(3) UNCLASSIFIED: " SUT-Y" (coded name) defeats XX% of specific U.S. landmine nomenclature at specific depths.

(4) UNCLASSIFIED: " SUT-Y" (coded name) defeats XX% of specific U.S. landmine nomenclature at generic depths.

(5) UNCLASSIFIED: Name of SUT defeats specific U.S. landmine nomenclature.

(6) UNCLASSIFIED: Name of SUT defeats XX% of generic U.S. landmine type at specific depths.

(7) UNCLASSIFIED: Name of SUT defeats XX% of generic U.S. landmine type at generic depths.

b. Statements regarding quantitative defeat performance at specific (quantitative) depths against specific models foreign landmines are SECRET. Statements regarding performance against generic foreign landmine types or generic depths (e.g., shallow or deep) or statements in which the system is not identified (unless it is identified in the larger context of a document) are UNCLASSIFIED. Examples are as follows:

(1) SECRET: Name of SUT defeats XX% of specific foreign landmine nomenclature at specific depths.

(2) UNCLASSIFIED: Name of SUT defeats XX% of specific foreign landmine nomenclature at generic depth.

APPENDIX H. DATA SECURITY CLASSIFICATIONS.

(3) UNCLASSIFIED: " SUT-Y" (coded name) defeats XX% of specific foreign landmine nomenclature at specific depths.

(4) UNCLASSIFIED: " SUT-Y" (coded name) defeats XX% of specific foreign landmine nomenclature at generic depths.

(5) UNCLASSIFIED: Name of SUT defeats specific foreign landmine nomenclature.

(6) UNCLASSIFIED: Name of SUT defeats XX% of generic foreign landmine type at specific depths.

(7) UNCLASSIFIED: Name of SUT defeats XX% of generic foreign landmine type at generic depths.

c. Statements regarding quantitative defeat performance at specific (quantitative) depths against specific electromagnetic hazard (EH) other than landmines (non-landmine EH), which are IEDs (high explosive component, excluding the trigger mechanism, see d below) are SECRET. Statements regarding performance against generic non-landmine EH or generic depths (e.g., shallow or deep) or statements in which the system is not identified (unless it is identified in the larger context of a document) are UNCLASSIFIED. Examples are as follows:

(1) SECRET: Name of SUT defeats XX% of specific non-landmine EH at specific depths.

(2) UNCLASSIFIED: Name of SUT defeats XX% of specific non-landmine EH nomenclature at generic depth.

(3) UNCLASSIFIED: "SUT Y" (coded name) defeats XX% of non-landmine EH nomenclature at specific depths.

(4) UNCLASSIFIED: "SUT Y" (coded name) defeats XX% of specific non-landmine EH nomenclature at generic depths.

(5) UNCLASSIFIED: Name of SUT defeats specific non-landmine EH nomenclature.

(6) UNCLASSIFIED: Name of SUT defeats XX% of generic non-landmine EH type at specific depths.

(7) UNCLASSIFIED: Name of SUT defeats XX% of generic non-landmine EH type at generic depths.

APPENDIX H. DATA SECURITY CLASSIFICATIONS.

d. Statements regarding quantitative defeat performance against specific trigger mechanisms used to actuate IEDs, regardless of depth, are SECRET. Statements regarding performance against trigger mechanisms in general, or statements in which the system is not identified (unless it is identified in the larger context of a document), are UNCLASSIFIED. Examples are as follows:

(1) SECRET: Name of SUT defeats XX% of (specific trigger mechanism description).

(2) UNCLASSIFIED: "SUT Y" (coded name) defeats XX% of (specific trigger mechanism description).

(3) UNCLASSIFIED: Name of SUT defeats (specific trigger mechanism description).

(4) UNCLASSIFIED: Name of SUT defeats XX% of trigger mechanism.

H.2. The release of all test data should be in accordance with the project Security Classification Guide and ATEC Reg 73-1[18].

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APPENDIX I. ABBREVIATIONS.

Aa	additional accurate detection
ACU	Army Combat Uniform
AEC	U.S. Army Evaluation Center
ANSI	American National Standards Institute
AP-LM	antipersonnel low metallic
AP-M	antipersonnel metallic
AR	Advance Rate
AT-LM	anti-tank low metallic
AT-M	anti-tank metallic
ATEC	U.S. Army Test and Evaluation Command
ATIRS	Army Test Incident Reporting System
BIT	Built-In Test
BITE	Built-In Test Equipment
C	Celsius
cm	centimeter
CM	counter measure
ConOps	Concept of Operations
CREW	counter radio electronic warfare
CTTR	Countermine Testing and Training Range
CW	continuous wave
DA PAM	Department of the Army Pamphlet
dB	decibel
D-GPS	differential global positioning system
E	East
E3	electromagnetic environmental effects
EM	electromagnetic
EMC	electromagnetic compatibility
EH	electromagnetic hazard
EMI	electromagnetic interference
EMR	electromagnetic radiation
F	Fahrenheit
FA	False Alarm
FAR	False Alarm Rate
FOUO	For Official Use Only
FSR	Field Service Representative
GPR	ground penetrating radar
GPS	global positioning system

APPENDIX I. ABBREVIATIONS.

HEMP	High altitude electromagnetic pulse
HERF	Hazards of Electromagnetic Radiation to Fuel
HERO	Hazards of Electromagnetic Radiation to Ordnance
HERP	Hazards of Electromagnetic Radiation to Personnel
HESD	Helicopter Electrostatic Discharge
IAW	in accordance with
ID	identification
IED	improvised explosive device
IRIG	Intra-Range Instrumentation Group
ITOP	International Test Operations Procedure
kg	kilogram
LED	light-emitting diode
LMPP	low metal pressure plate
LS	logistic support
m	meter
MANPRINT	Manpower and Personnel Integration
MIL-STD	Military Standard
mm	millimeter
MMC	metal main charge
MOPP	mission oriented protective posture
MRAP	mine-resistant ambush protected
MSDS	material safety data sheet
N	North
NATO	North Atlantic Treaty Organization
NBC	nuclear, biological, chemical
NMMC	no metal main charge
NMPP	no metal pressure plate
OM	Operator Manual
OPSEC	Operations Security
P_d	probability of detection
P_D	performance of detection
PD	percent detection
PEL	personnel exposure limits
PESD	personnel electrostatic discharge
P_{fa}	probability of false alarm

APPENDIX I. ABBREVIATIONS.

PHA	Preliminary Hazard Assessment
PII	personal identification information
PM	Program Manager
PMCS	preventive maintenance checks and services
PPIED	pressure-plate improvised explosive device
QA	quality assurance
QC	quality control
RAM	reliability, availability, and maintainability
RCIED	remote controlled improvised explosive device
RCRIT	critical radius
REC	Record of Environmental Consideration
Reg	regulation
RF	radio frequency
ROA	rate of advance
ROC	Receiver Operating Characteristic
S	South
SAR	Safety Assessment Report
ScR	scan rate
SME	subject matter expert
SMO	Spectrum Management Office
SNR	signal-to-noise ration
SOC	state of charge
SOP	Standard Operation Procedure
SR	Safety Release
SSP	system support package
STANAG	Standardization Agreement
SUT	system under test
SwR	sweep rate
TEMP	Test and Evaluation Master Plan
TIR	test incident report
TM	Technical Manual
TOP	Test Operations Procedure
TSARC	Test Schedule and Review Committee
USCS	Unified Soil Classification System
UTM	Universal Transverse Mercator
W	West
WGS	World Geodetic System

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APPENDIX J. REFERENCES.

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13. TOP 01-2-610, Human Factors Engineering (Part I and Part II), 15 May 1990.

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APPENDIX J. REFERENCES.

17. MIL-STD-461F, Department of Defense Interface Standard: Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment, 10 December 2007.

18. ATEC Reg 73-1, Test and Evaluation: System Test and Evaluation Policy, 22 March 2013.

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a. MIL-STD-882E, Department of Defense Standard Practice: System Safety, 11 May 2012.

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APPENDIX K. APPROVAL AUTHORITY.

CSTE-TM 8 January 2015

MEMORANDUM FOR

Commanders, All Test Centers
Technical Directors, All Test Centers
Directors, U.S. Army Evaluation Center
Commander, U.S. Army Operational Test Command

SUBJECT: Test Operations Procedure (TOP) 04-2-090A, Testing of Hand Held Mine Detection Systems, Approved for Publication

1. TOP 04-2-090A, Testing of Hand Held Mine Detection Systems, has been reviewed by the U.S. Army Test and Evaluation Command (ATEC) Test Centers, the U.S. Army Operational Test Command, and the U.S. Army Evaluation Center. All comments received during the formal coordination period have been adjudicated by the preparing agency. The scope of the document is as follows:

The purpose of this TOP is to provide the tester standardized testing methodologies and procedures to assess handheld detection systems in order to test the overall safety, performance, and reliability of the system. It describes activities necessary to ensure safety is designed into the system under test, and to verify detection performance meets system requirements (to detect landmines, improvised explosive devices and their components, as well as ammunition cache and unexploded ordnance).

2. This document is approved for publication and has been posted to the Reference Library of the ATEC Vision Digital Library System (VDLS). The VDLS website can be accessed at https://vdls.atc.army.mil/.

3. Comments, suggestions, or questions on this document should be addressed to U.S. Army Test and Evaluation Command (CSTE-TM), 2202 Aberdeen Boulevard-Third Floor, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to usarmy.apg.atec.mbx.atec-standards@mail.mil.

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Range Infrastructure Division (CSTE-TM), U.S. Army Test and Evaluation Command, 2202 Aberdeen Boulevard, Aberdeen Proving Ground, Maryland 21005-5001. Technical information may be obtained from the preparing activity: TEDT-YPY-MWM (Munitions and Weapons Division), U.S. Army Yuma Proving Ground, Yuma, Arizona 85365. Additional copies can be requested through the following website: http://www.atec.army.mil/publications/topsindex.aspx, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.